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CAMEO OF THE EMPEROR AUGUSTUS IN THE BLACAS COLLECTION.

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(*With a Coloured Plate.*)

PERHAPS the most important of the additions made to the antiquarian department of the British Museum of late years was by the purchase entire, for the sum of sixty thousand pounds, of one of the best known collections in France, the antiquities of the Duc de Blacas. The French antiquaries, who regret greatly that they let this interesting collection slip out of their hands, praise our own negotiators for the skill and energy they displayed throughout the whole affair. The duc, who, since the overthrow of the elder branch of the Bourbons in France, had withdrawn from anything like political activity, devoted his time and wealth to his museum, to which most of the collections sold during his time contributed more or less largely. He purchased the whole Strozzi collection, from Rome, with the exception of one beautiful gem, representing the young Hercules (*Hercules juvenis*), engraved on a sapphire, and bearing the name of the engraver in Greek letters, ΓNAIOC (*Cneius*). While the collection was still in the possession of Strozzi, this fine work of art was stolen, and a copy in glass left in its place. Years after, when the collection had passed to the Duc de Blacas, who imagined that he possessed the original gem, he was surprised at seeing it brought to him, and, discovering the fraud, he succeeded in obtaining possession of it by purchase. This original is now with the rest of the collection in the British Museum. His taste as a collector appears to have run chiefly upon three classes of objects, Greek and Etruscan vases, engraved and sculptured gems, and early personal ornaments of gold. The first of these three classes, that of the vases, has been made better known to the public than the others through

the works of Panofka, De Witte, and others; and some of the finest of the gems in the Blacas collection having been derived from the older and better known Strozzi collection, have been spoken of in different works on this branch of ancient art, but otherwise the contents of the museum of which we are speaking are not very generally known. It was from the Strozzi collection that the duc obtained the noble cameo of Augustus, represented in our accompanying plate.

So much has been written on the history of precious stones and of the lapidary's art, that it is now hardly required, in treating of a subject like this, to go at any length over ground which has been so well trodden before. The ancients themselves had abundance of wonderful stories of the immense values set upon particular precious stones, and of the singular parts they had sometimes played in history. Pliny the Elder, in his chapters on this subject (*Hist. Nat.*, lib. xxxvii.), tells us that it was the common belief that the first individual who wore a ring with a stone in it was Prometheus, who had been condemned by Jupiter to carry on his finger, as a memorial of his offences, a bit of the rock of Caucasus set in a ring of iron; and this, he tells us, was, according to the tradition, "the first ring and the first jewel known." But Pliny adds that, in this case, he disbelieved the tradition, and that his opinion was that this ring of Prometheus was only that of the chain by which he was bound to the rock. The same writer tells us next of the celebrated jewel of Polycrates, the tyrant of Samos, upon which so much value was set that he imagined that the voluntary loss of it would be a sufficient expiation to the inconstancy of Fortune to avert her wrath, and he went out to sea, and threw the ring containing the jewel into the waves. But the fickle goddess refused to accept it; a large sea-fish, served at the king's table, was found, when carved, to contain in its belly the fatal jewel, which was restored to the king; and the latter, in the sequel, ended his life miserably. Pliny tells us that this precious stone was a sardonyx, which was still in his time preserved at Rome, where it had been given as part of the ornamentation of a horn to the Temple of Concord by the Emperor Augustus, and he says that it was there considered as much inferior to many other jewels then collected in the Roman capital. It was reported, a few years ago, that the ring of Polycrates had been found in a vineyard near Rome, by a vine-dresser of Albano; but as it was described as a very fine intaglio, with the name of the artist, it is probable that the whole story was a fiction, or the ring a forgery.

The object of the first people who made use of precious stones, was of course to display the stones themselves, on account of their beauty and the great value set upon them. Pliny,

launching out into admiration on this subject, says that a precious stone is an object "in which the majestic might of nature presents itself to us, contracted within a very limited space, though, in the opinion of many, nowhere displayed in a more admirable form." Many people, he says, looked upon it as no less than sacrilege to engrave them, even for signets, although he considers that the especial purpose for which they were created. In another part of his great work (*Hist. Nat.*, lib. xxxiii. c. 4), Pliny recurs to the ring of Prometheus, mentioned above, and to rings of iron and of gold. As might be expected, some of these primeval rings became celebrated for qualities which were more than natural. Midas, according to our writer—others say Gyges—had a ring which, upon the collet being turned inwards, caused the wearer to become invisible. The only rings known among the early Romans, were of iron, and even they only came into use at rather a late period. At the very close of the republic, a gold ring was only made use of on public and ceremonious occasions of great importance. The *annulus pronubus*, which was sent as a present to a betrothed woman, as a sign of her engagement, was only of iron. Pliny believed that the use of rings had not existed even in Greece at the time of the Trojan war, and he tells us that the first date in Roman history at which he could trace any general use of them was in A.U.C. 449, in the time of Cneius Flavius, the son of Annius. Yet, as he adds, after this date they must have come into use very rapidly, for, in the second Punic war, they were so abundant that Hannibal was able to send from Italy to Carthage three modii of them. The next advance in luxury was the practice of inserting or setting a precious stone in the gold of the ring, and it was not till a still later period that the use of signet rings was adopted, which implied the engraving of a device, of some kind or other, on the stone of the ring. Pliny tells us distinctly that the stone of the ring of Polycrates, or at least the one shown for it at Rome in his time, presented no traces of engraving.

The first engraved gem he mentions belonged to Pyrrhus, king of Epirus, the great enemy of the Romans. This was in the first half of the third century before Christ, and the history of precious stones was still involved in so much mystery, that King Pyrrhus was believed to have in his possession an agate (*achates*) on which were figured the nine muses, with Apollo holding a lyre, the work not of the engraver, but of nature herself, the veins of the stone being so arranged naturally, that each of the muses had her own peculiar attribute. At a later period, notions like this prevailed extensively, and in the more ignorant periods of the

middle ages, people believed that the ancient intaglios and cameos, which were often found in digging the ground on ancient sites, were natural objects, and that engraving on them was a mere natural indication of the special power or quality each possessed. Some of the mediæval writers believed that the *fidus Achates* of Roman fable was nothing but a precious *agate*, on which depended the fortunes of Æneas.

We know nothing of the first beginnings of the art of engraving upon precious stones, but it appears to have come from the East. Pliny, who is our chief authority on these matters, mentions an edict of Alexander the Great, forbidding the engraving of his portrait on a smaragdus (supposed to be the emerald) by any other professor of the art but Pyrgoteles. We seem from this justified in supposing that, in the age of Alexander, the art of engraving on gems was extensively practised in Greece. Less than a century before Christ, Mithridates, the celebrated king of Pontus, possessed a dactyliotheca, or museum of signet rings. With Augustus and the earlier Roman emperors, the possession of these dactyliothecæ became a great subject of pride, and the Romans displayed a sort of wild extravagance in their taste for possessing cameos and intaglios, and in the immense sums they gave for them. The first who formed a dactyliotheca at Rome was Scaurus, the stepson of the dictator Sylla, but all we know of it is the statement of Pliny, that it was much inferior to that of Mithridates, which latter was transferred to Rome by Pompey the Great, the conqueror of Mithridates, and presented by him to the capitol.

The contents of the dactyliothecæ appears to have been little appreciated by the Barbarians, and, after the fall of the empire of the West, the taste for this branch of art was carried to Byzantium, whence it returned to Western Europe in the fifteenth century. Yet the people of the middle ages, with that mysteriously superstitious regard for them already noticed, sought eagerly to be possessed of them. It is very common to find a great baron or knight, or an ecclesiastic, sealing his charter or other document with a seal in which an ancient intaglio is set instead of an ordinary mediæval seal. Perhaps he thought that, being an object of comparative rarity, the possession of it was something to be proud of; but it is probable also, that he looked upon it as possessing some superior power which gave him protection or security. In this belief, catalogues of intaglios and cameos, with lists of their several qualities, or virtues, were published, and are sometimes found in mediæval manuscripts. But the ecclesiastics made the greatest profit of them in this point of view, for they collected them in their churches and monasteries, gave out that they were en-

dowed severally with the power of curing different diseases by their mere application, and demanded good fees for applying them. We might quote many such curative properties of individual gems, some of which are undignified enough. A fine cameo possessed by the monks of St. Alban's, and probably derived from the ruins of Verulamium, was believed to give ease to women in the pains of childbirth, and was lent on such occasions—no doubt for a consideration. Another very handsome cameo, described by one of the modern writers on this subject, was looked upon with regard as a preservative against rats! Among a great number of such objects formerly preserved in the treasury of the Cathedral of St. Paul's in London, one, which bore a figure of Andromeda, had the power of raising love between man and woman; one with the figure of a hare was a protective against the devil; a dog and a lion on the same stone preserved against dropsy; the figure of Orion gave to one of these stones the quality of securing victory in war; in another the figure of a syren, sculptured in a jacynth, rendered the bearer invisible.

It was in a great measure out of these mediæval collections of gems, ecclesiastical or lay, the result of mere accidental finds, that our modern collections have been formed, with the addition of others found in antiquarian excavations of a later date, and they are thus, more or less, of a very miscellaneous character. The dactyliotheca of the Roman age, if collected by a man of taste, would contain nothing but stones of the highest degree of art, and even if he erred in judgment himself, he could find an adviser who would assist him; he did not collect his specimens by chance, glad to get all that came to hand, but sought them from the best sources, so that he had probably nothing but what was good. It is different with the modern collector. The cameos and intaglios which are brought to light by ordinary antiquarian excavations are, for the most part, of a very low degree of merit, such as no doubt were possessed by people of the commoner classes. The modern collector has little but these to collect from, and not in such abundance but that he is glad to get all he can, or at best to pick out here and there any one which seems better than the others, and wait for a rare chance of obtaining something of a very superior character. Such is the general character of the contents of most modern cabinets, and especially of such as have been made by private collectors; and such, no doubt, is the cabinet of intaglios and cameos of the Duc de Blacas. It contains a certain number of very fine works of art, among a large quantity of specimens of very ordinary merit. This is especially the case among the intaglios, which may perhaps be said to be the case generally. The stones necessary for the

cameos were rarer than the others, and were probably seldom given to the artists of inferior merit who employed themselves on intaglios, and the two processes differed considerably in the manner of carrying them into execution. In modern excavations on ancient sites, an intaglio is often found, but a cameo very rarely. Even now we do not know where the Romans obtained the large sardonyxes on which they engraved the fine cameos which are preserved.

The sardonyx on which the fine head of Augustus in the Blacas collection is engraved forms an oval, five inches and a quarter in length, by three inches and three quarters in breadth, and is of very good quality. The ground, or layer, of the stone out of which the head rises is of a fine russet colour, which throws the engraving into very delicate, though rather low relief. A head of Medusa appears to form the centre of the shield which covers the breast. Augustus has a band, or fillet, round his head, the sign of his imperial dignity, on which are set four precious stones, an emerald on the left, and, following it in their order towards the right, a sapphire, a topaz, and a ruby, and round the figure in the middle are arranged four very small diamonds. In the collection of the Imperial Library at Paris, there are several cameos as large, and perhaps a little larger, than the Augustus of the Blacas collection, but there is hardly one of them that equals it, and certainly not one that excels it as a work of art. The expression of the countenance is brought out with great delicacy and refinement, and the artist has displayed the greatest skill in taking advantage of the colours and shades offered him by the stone. Little appears to be known of the history of this remarkable work of art, except that it was formerly in the Strozzi collection.

The age of Augustus is said to have been that at which the art of engraving precious stones was carried to the highest degree of excellence among the Romans, and we need not therefore be surprised if we find so many of them representing the features of that emperor. Pliny (xxxvii. 4) celebrates the merits of a portrait of Augustus by an engraver named Dioscorides, which was used as the signet of the emperors who succeeded him. One of the finest cameos known is a tri-coloured sardonyx, about a foot high, representing, in twenty-two figures, the apotheosis of the Emperor Augustus, and which was therefore probably engraved soon after his death. It was brought from Constantinople in the reign of St. Louis, and being, in the ignorance of that time, supposed to represent the triumph of Joseph over Pharaoh, it was considered to regard the church more than the laity, and was placed by that monarch among the treasures of the Sainte Chapelle in Paris.

It is now preserved in the Bibliothèque Impériale. In the same case with the large cameo of Augustus in the Blacas collection there is a small one, of the same emperor, also on sardonyx, which came likewise from the Strozzi cabinet.

The choicest examples of the Blacas collection are arranged in two cases, at the two ends of a box or frame, one with the large cameo of Augustus in the centre, looking towards the entrance-door, the other in the opposite direction. The first contains forty intaglios and cameos, and among the latter, besides the two already described, a cameo on sardonyx, representing a portrait of Tiberius, also from the Strozzi collection, which strikes us by its wonderful relief, but it has suffered much from rubbing. Among the intaglios in this case are a portrait of Julius Cæsar engraved in jacynth, the features of which are wonderfully sharp and delicate; a Silenus, on cornelian, with full face, remarkably fine; another Silenus, side face, on amethyst, which is also finely executed, and has the name of the engraver inscribed in Greek letters, Hyllus; and a Mænad, whose wild and drunken fury, and the voluptuous fleshiness of her bosom, are represented with extraordinary effect. The other select case contains forty-two examples. It also has its large cameo, well executed, on a sardonyx about five inches high, representing the Empress Messalina. The portrait of Juba II. is represented in a delicate little cameo on sardonyx. A head of Livia, on cornelian, is also worthy of our notice, because the head is in intaglio, surrounded by a border in cameo. This also came from the Strozzi collection. Among the intaglios in this case, we may call attention to a female head in cornelian, with a sweet little face; a very characteristic portrait of Vespasian, in cornelian; and a small head of Horace, in topaz, of considerable merit. There is also in this case what is called an amulet, in cornelian, formed in the shape of the petal of a flower (perhaps intended for a rose), with two small Cupids, very prettily executed in intaglio.

The rest of the intaglios of the Blacas collection, with two or three cameos, are placed in three large cases, upon tables, on the other side of the room, and are mostly of inferior work. Many of them have suffered from rubbing and ill-usage. They amount in all to 384. We may, in passing over them, point out to notice No. 20, a neat little cameo of a horse, of tolerably good work, and No. 245, a sardonyx remarkable for its neat border of astragals.

In the course of collecting, the Duc de Blacas embraced a taste for acquiring a class of monuments which were then comparatively little thought of, those of the earlier ages of Mahometanism, which are intimately connected with the present article

by the circumstance that among them the intaglios, or engraved stones, hold a very prominent place. The duc was one of the earlier friends of the late accomplished and lamented professor of Arabic in Paris, M. Reimaud, who, at one time, might almost be looked on as the keeper of his Mussulman antiquities, and who, in 1828, published, in two octavo volumes, a very learned description of them, under the title of *Monumens Arabes, Persans, et Turcs, du Cabinet de la Duc de Blacas et d'Rures Cabinets.* The choice Mahometan intaglios of the Blacas collection are engraved and described in this work. We know that, at an early period, the intaglios had been imitated by many of the eastern religious sects in the form of cabalistic seals, some of which are found in the Blacas collection, which are known by the name of Abraxas. The Mahometans also, no doubt, borrowed the practice of engraving on precious stones from the Romans and Greeks, and they used them for the same purposes, as signets and seals, but they presented one special point of difference with both the seals of the Greeks and Romans, and with the Abraxas, a difference which of course belonged to their religious ideas. They are distinguished by the total absence of all figures, only letters being engraved upon them. These inscriptions are generally of a more or less religious character, consisting usually of short invocations or reflections, pious, moral, or superstitious. A few of the older ones are of a talismanic, astrologic, or cabalistic character.

CHEMICAL AIDS TO ART.—No. II.

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I PURPOSE describing, on the present occasion, several methods for the permanent artistic decoration of wall surfaces. In our climate the processes of distemper and fresco painting have some serious drawbacks. The size used with the colours in distemper is liable to perish, while the dust and soot which accumulate on the decorated surfaces cannot be removed by any cleaning process, save, to a certain extent, by washes of spirits of wine. Besides the mechanical difficulties of fresco painting, which often hinder so seriously the artistic perfection of the works executed by this method, it is by no means certain that the painting will be permanent, even when every care has been taken. The experience of Italy in this matter must not be accepted as a sure guide for our own artists. The enormous size of our great cities, and the vast amount of coal and gas consumed in them, render their atmospheric conditions very unfavourable for the permanence of works in fresco. As such artistic works will probably for some time to come be executed only in large towns, it is greatly to be desired that some process of painting at once easy and permanent, could be devised. Many attempts have been made in this direction, and the success already attained has been, no doubt, considerable. I shall describe the chief features of several more or less novel processes of wall painting, pointing out here and there their advantages and disadvantages, and also offering, where practicable, some hints for their alteration and improvement.

As a new method of painting, intimately depending on recently discovered chemical facts, first and foremost stands the process called water-glass fresco, or stereochromy. The plastered wall is partially saturated with a weak solution of the soluble silicate of potash (made by boiling calcined flints, which have been *étonné* in cold water, with caustic potash under pressure); the wall is allowed to dry, and then the painting is commenced. Ordinary fresco colours are employed, but the only white to be used is zinc white. Some colours, those which are affected by alkalies, cannot, however, be used with success. Among these, the chrome yellows, the lakes, several of the madder colours, and all the copper and arsenical greens, are inadmissible. All colours, on the other hand, which are not acted upon by alkalies, such as vermilion, smalt and chrome green, with the yellows and reds made from iron oxides

and ivory black, with burnt siena, burnt umber, and similar preparations, may all be fixed to the prepared wall surface without injury. A great difficulty will be experienced at first in laying on the colours, since no medium but water or lime-water is admissible. By keeping the wall constantly wet with lime-water, or baryta-water, this difficulty may be partially removed. All the water used in the process, from the preparation or priming of the walls to the final fixing of the coloured surface, must be pure distilled water. This final fixing of the painting is accomplished as follows:—A weak solution of pure silicate of potash is prepared (several applications of a weak solution are much more effective than two or three applications of a strong liquor) by mixing the ordinary liquid silicate of potash of commerce with thrice its bulk of water. It is of course impossible to lay on the fixing liquor with a brush, which would infallibly cause the removal of much of the colour. A complicated spray-producer, or syringe of peculiar construction, was invented for the purpose, and has been used extensively. But I have found that a very cheap and effective instrument may be made by attaching, with an India-rubber tube, a small pair of hand bellows to the little contrivance familiarly known as La Bouffée, or L'Odorateur. The apparatus should be examined carefully to see that no drop of liquid—nothing but spray—is blown against the painting. The syringing is renewed at intervals of a few days, till—when the painting is dry—a wet cloth removes no particle of colour. Over-silication will produce a glaze which renders the surface spotty, and unpleasant in appearace. No re-touching, after fixing, is permissible, unless the old colour be first removed by scraping. Any soluble efflorescence which may make its appearance on the wall in the course of a few months, may be removed by a thorough washing of the surface with hot distilled water; indeed this treatment is in all cases desirable. Another kind of efflorescence also occasionally makes its appearance. This latter substance is, unfortunately, insoluble in water and all usual solvents, and can scarcely be removed even by mechanical means. It consists chiefly of an insoluble silicate, and seems to arise from an insufficiency of alkali in the water-glass used. For it is a great mistake to suppose that the excess of potash in the original silicate can be safely removed, as some chemists have recommended, by the addition to it of gelatinous silica, or of a diluted solution of silica. Indeed, on the other hand, the introduction of a small quantity of caustic potash to the diluted medium is often desirable. When this second kind of efflorescence has once appeared, the unpleasant bloom which it imparts to the painting may be partially obviated by syringing

the surface with pale copal varnish, diluted with twice or thrice its own bulk of spirits of turpentine.

Since Professor J. Fuchs, of Munich, published his important paper on Water Glass (in 1825), this process, in which it is artistically employed, has developed greatly in the hands of Kaulbach, and other German artists, at Berlin and Munich, and also in this country likewise. Maclise, for instance, has worked most successfully with it in the Royal Gallery of the House of Lords, but it remains to be proved that the works of these artists are safe against all the evils of the process. The silicious bloom has, in several instances, appeared upon the works of those who are thoroughly well versed in all the minute details of the process. It is probable that the method will have to be modified greatly, so as to get rid of its technical difficulties and its chemical defects before it can command the general confidence of artists. In some of the other processes which we will now describe, there probably exist the germs of real improvements in these particulars. Professor Kuhlmann, of Lille, suggested, some years ago, the combined use of silicate of potash and aluminate of potash for the fixation of colours, as well as for the hardening of stone. One great objection to this process, in which the colours are mixed with a solution containing both silicate and aluminate of potash, is the excessive alkalinity of the preparation. The union of these two caustic potash compounds yields a solid glassy substance, but this compound is far from being analogous, as has been alleged, to felspar in its constitution, for it contains many times as much alkali as that mineral. Nor is it wholly unchangeable, for it spontaneously undergoes a process of disintegration, although this does not occur generally for some time. A wall decorated by this process never dries, and retains its alkalinity for years, as may be easily shown by placing a piece of moist yellow turmeric paper upon the painted surface; the alkali will change the yellow of the turmeric paper into brown.

But if we leave the soluble silicates altogether, we shall find that there are other chemical compounds which can effect the same objects. If a ground for painting be prepared with lime, whitening, and sand, and the colours be mixed with a five per cent. solution of soluble phosphate of lime instead of with water, they will readily adhere, while no soluble salts whatever will be formed in the wall, insoluble bone-phosphate only being produced. Good proportions for the plaster are three parts of burnt lime and two of whitening, both ground together into a fine powder; five parts of pure sand, or of marble grit, are then mixed with this powder, and the whole made into a paste with baryta-water. This material is spread

in a thin layer upon the wall, and when dry affords a most retentive ground, which should be moistened with distilled water before it is painted upon. Nearly all the good vegetable colours, and many other pigments which are inadmissible in the two former methods of wall painting, may be freely used in this third method. Any portion of the picture not fixed when dry should be syringed with the soluble phosphate liquor till the desired effect is produced. Alternate syringings with phosphate liquor and baryta-water are very effective occasionally, but they lighten the shade of colour to which they are applied considerably. This process admits of much further elaboration, and, probably, of great and beneficial improvements. The soluble phosphate solution may be made by boiling one ounce of the best superphosphate of lime in three ounces of water: when the mixture is cold, the clear liquor is poured off for use.

A fourth process will lastly demand a brief notice; it is not essentially a new method, and can scarcely claim to be dependent upon a chemical action, similar to those which take place in the methods already described. It may be termed the copal process. Mr. Gambier Parry, the well-known amateur artist, has developed this method, and we shall follow his directions in describing how it is to be carried out. A dry wall is necessary. Ordinary plaster (not whitening), free from salt, etc., is the surface on which the painting is to be executed. The colours are not mixed with oil, but with a medium thus made: take of white wax, four ounces by weight; elemi resin, one ounce by weight. These substances are to be melted together, and strained hot through muslin; they are then to be incorporated, by careful heating, with oil of spike lavender, six ounces by measure; fine copal varnish, twenty-two ounces by measure. When the mixture is uniform, it is to be allowed to cool, and is then ready for use. The colours should be ground with it, and be preserved in covered pots. The surface is prepared by saturating it with two or three washes of the above medium, diluted with half its bulk of spirits of turpentine. The colours may be thinned, and the brushes cleaned with oil of spike or of turpentine; but all kinds of fixed oil must be excluded. This process admits of the highest technical excellence, and, although the painted surface does not acquire a rocky hardness, like that of the stereochromic and similar methods, it is certainly far less liable to change, and has a more complete hold of the wall than any ordinary system of applying colours. Very good examples of this method are to be seen in Mr. Parry's church, at Highnam, near Gloucester, and more especially in one of the southern chapels of Gloucester Cathedral.

The method, slightly modified, is also applicable—where most processes fail—to the retention and restoration of ancient ecclesiastical frescoes. In using the process, both for original work and for restorations, I confess I prefer to adopt a somewhat different plan for preparing the medium. I find the following directions to yield an excellent product, and to be very easy to carry out:—Dissolve three-quarters of an ounce of elemi in six ounces of oil of spike, in a flask, by the aid of heat: the fragments of bark in the elemi will sink to the bottom of the vessel; melt three ounces of white wax and one ounce of pure white paraffine in another flask; mix the two liquids together, and allow the impurities to settle. Put twenty-two liquid ounces of fine pale copal varnish—picture copal—in a tin can; keep the can plunged in boiling water for half an hour or more; pour the elemi and wax mixture (also hot), into the can, stir it, and keep warm some time longer. This preparation may be used, diluted, etc., exactly as previously directed.

THE PHILOSOPHY OF BIRDS' NESTS.

BY ALFRED R. WALLACE, F.Z.S., ETC.

BIRDS, we are told, build their nests by *instinct*, while man constructs his dwelling by the exercise of *reason*. Birds never change, but continue to build for ever on the self-same plan; man alters and improves his houses continually. Reason advances; instinct is stationary. This doctrine is so very general that it may almost be said to be universally adopted. Men who agree on nothing else, accept this as a good explanation of the facts. Philosophers and poets, metaphysicians and divines, naturalists and the general public, not only agree in believing this to be probable, but even adopt it as a sort of axiom that is so self-evident as to need no proof, and use it as the very foundation of their speculations on instinct and reason. A belief so general, one would think, must rest on indisputable facts, and be a logical deduction from them. Yet I have come to the conclusion that not only is it very doubtful, but absolutely erroneous; that it not only deviates widely from the truth, but is in almost every particular exactly opposed to it. I believe, in short, that birds do *not* build their nests by instinct; that man does *not* construct his dwelling by reason; that birds do change and improve when affected by the same causes that make men do so; and that mankind neither alter nor improve when they exist under conditions similar to those which are almost universal among birds.

Let us first consider the theory of reason, as alone determining the domestic architecture of the human race. Man, as a reasonable animal, it is said, continually alters and improves his dwelling. This I entirely deny. As a rule, he neither alters nor improves, any more than the birds do. What have the houses of most savage tribes improved from, each as invariable as the nest of a species of bird? The tents of the Arab are the same now as they were two or three thousand years ago, and the mud villages of Egypt can scarcely have improved since the time of the Pharaohs. The palm-leaf huts and hovels of the various tribes of South America and the Malay Archipelago, what have they improved from since those regions were first inhabited? The Patagonian's rude shelter of leaves, the hollowed bank of the South African Earthmen, we cannot even conceive to have been ever inferior to what they now are. Even nearer home, the Irish turf cabin and the Highland stone shelty can hardly have advanced much during the last two thousand years. Now, no one imputes this stationary condition of domestic architecture among these savage tribes to instinct, but to simple imitation from one generation to another, and the absence of any sufficiently powerful stimulus to change or improvement. No one imagines that if an infant Arab could be transferred to Patagonia or to the Highlands, it would, when it grew up, astonish its foster-parents by constructing a tent of skins. On the other hand, it is quite clear that physical conditions, combined with the degree of civilization arrived at, almost necessitate certain types of structure. The turf, or stones, or snow—the palm-leaves, bamboo, or branches, which are the materials of houses in various countries, are used because nothing else is so readily to be obtained. The Egyptian peasant has none of these, nor even wood. What, then, can he use but mud? In tropical forest countries, the bamboo and the broad palm-leaves are the natural material for houses, and the form and mode of structure will be decided in part by the nature of the country, whether hot or cool, whether swampy or dry, whether rocky or plain, whether frequented by wild beasts, or whether subject to the attacks of enemies. When once a particular mode of building has been adopted, and has become confirmed by habit and by hereditary custom, it will be long retained, even when its utility has been lost through changed conditions, or through migration into a very different region. As a general rule, throughout the whole continent of America, native houses are built directly upon the ground—strength and security being given by thickening the low walls and the roof. In almost the whole of the Malay Islands, on the contrary, the houses are raised on posts, often to a great height, with an

open bamboo floor; and the whole structure is exceedingly slight and thin. Now, what can be the reason of this remarkable difference between countries many parts of which are strikingly similar in physical conditions, natural productions, and the state of civilization of their inhabitants? We appear to have some clue to it in the supposed origin and migrations of their respective populations. The indigenes of tropical America are believed to have immigrated from the north—from a country where the winters are severe, and raised houses with open floors would be hardly habitable. They moved southwards by land along the mountain ranges and uplands, and in an altered climate continued the mode of construction of their forefathers, modified only by the new materials they met with. By minute observations of the Indians of the Amazon Valley, Mr. Bates arrived at the conclusion that they were comparatively recent immigrants from a colder climate. He says:—"No one could live long among the Indians of the Upper Amazon without being struck with their constitutional dislike to the heat. . . . Their skin is hot to the touch, and they perspire little. . . . They are restless and discontented in hot, dry weather, but cheerful on cool days, when the rain is pouring down their naked backs." And, after giving many other details, he concludes, "How different all this is with the Negro, the true child of tropical climes! The impression gradually forced itself on my mind that the Red Indian lives as an immigrant or stranger in these hot regions, and that his constitution was not originally adapted, and has not since become perfectly adapted, to the climate."

The Malay races, on the other hand, are no doubt very ancient inhabitants of the hottest regions, and are particularly addicted to forming their first settlements at the mouths of rivers or creeks, or in land-locked bays and inlets. They are a pre-eminently maritime or semi-aquatic people, to whom a canoe is a necessary of life, and who will never travel by land if they can do so by water. In accordance with these tastes, they have built their houses on posts in the water, after the manner of the lake-dwellers of ancient Europe; and this mode of construction has become so confirmed, that even those tribes who have spread far into the interior, on dry plains and rocky mountains, continue to build in exactly the same manner, and find safety in the height to which they elevate their dwellings above the ground.

These general characteristics of the abode of savage man will be found to be exactly paralleled by the nests of birds. Each species uses the materials it can most readily obtain, and builds in situations most congenial to its habits. The wren, for example, frequenting hedgerows and low thickets, builds

its nest generally of *moss*, a material always found where it lives, and among which it probably obtains much of its insect food; but it varies sometimes, using hay or feathers when these are at hand. Rooks dig in pastures and ploughed fields for grubs, and in doing so must continually encounter *roots* and *fibres*. These are used to line its nest. What more natural! The crow, feeding on carrion, dead rabbits, and lambs, and frequenting sheep-walks and warrens, chooses *fur* and *wool* to line its nest. The lark frequents cultivated fields, and makes its nest, on the ground, of grass lined with *horsehair*—materials the most easy to meet with, and the best adapted to its needs. The kingfisher makes its nest of the *bones* of the fish which it has eaten. Swallows use clay and mud from the margins of the ponds and rivers over which they find their insect food. The materials of birds' nests, like those used by savage man for his house, are, then, those which come first to hand; and it certainly requires no more special instinct to select them in the one case than in the other. But, it will be said, it is not so much the materials as the form and structure of nests, that vary so much, and are so wonderfully adapted to the wants and habits of each species; how are these to be accounted for except by instinct? I reply, they may be in a great measure explained by the general habits of the species, the nature of the tools they have to work with, and the materials they can most easily obtain, with the very simplest adaptations of means to an end quite within the mental capacities of birds. The delicacy and perfection of the nest will bear a direct relation to the size of the bird, its structure and habits. That of the wren or the humming-bird is perhaps not finer or more beautiful in proportion than that of the blackbird, the magpie, or the crow. The wren, having a slender beak, long legs, and great activity, is able with great ease to form a well-woven nest of the finest materials, and places it in thickets and hedgerows which it frequents in its search for food. The titmouse, haunting fruit-trees and walls, and searching in cracks and crannies for insects, is naturally led to build in holes where it has shelter and security; while its great activity, and the perfection of its tools (bill and feet), enable it easily to form a beautiful receptacle for its eggs and young. Pigeons, having heavy bodies, and weak feet and bills (imperfect tools for forming a delicate structure), build rude, flat nests of sticks, laid across strong branches which will bear their weight and that of their bulky young. They can do no better. The *Caprimulgidæ* have the most imperfect tools of all, feet that will not support them except on a flat surface (for they cannot truly perch), and a bill excessively broad, short, and weak, and almost hidden by feathers and

bristles. They cannot build a nest of twigs or fibres, hair or moss, like other birds, and they therefore generally dispense with one altogether, laying their eggs on the bare ground, or on the stump or flat limb of a tree. The hooked bills, short necks and feet, and heavy bodies of parrots, render them quite incapable of building a nest like most other birds. They cannot climb up a branch without using both bill and feet; they cannot even turn round on a perch without holding on with their bill. How, then, could they inlay, or weave, or twist the materials of a nest? Consequently, they all lay in holes of trees, the tops of rotten stumps, or in deserted ants' nests, the soft materials of which they can easily hollow out.

Now I believe that throughout the whole class of birds the same general principles will be found to hold good, sometimes distinctly, sometimes more obscurely apparent, according as the habits of the species are more marked, or their structure more peculiar. It is true that, among birds differing but little in structure or habits, we see considerable diversity in the mode of nesting, but we are now so well assured that important changes of climate and of surface have occurred within the period of existing species, that it is by no means difficult to see how such differences have arisen. Habits are known to be hereditary, and as the area now occupied by each species is different from that of every other, we may be sure that such changes would act differently upon each, and would often bring together species which had acquired their peculiar habits in distinct regions and under different conditions.

But, it is objected, birds do not *learn* to make their nest as man does to build, for all birds will make exactly the same nest as the rest of their species, even if they have never seen one, and it is instinct alone that can enable them to do this. No doubt this would be instinct if it were true, and I simply ask for proof of the fact. This point, although so important to the question at issue, is always assumed without proof, and even against proof, for what facts there are, are opposed to it. Birds brought up from the egg in cages do not make the characteristic nest of their species, even though the proper materials are supplied them, and the experiment has never been fairly tried of turning out a pair of birds so brought up into an enclosure covered with netting, and watching the result of their untaught attempts at nest-making. With regard to the song of birds, however, which is thought to be equally instinctive, the experiment has been tried, and it is found that young birds never have the song peculiar to their species if they have not heard it, whereas they acquire very easily the song of almost any other bird with which they are brought up. It is also especially worthy of remark that they must be taken

out of hearing of their parents very soon, for in the first three or four days they have already acquired a knowledge of the parent notes, which they will afterwards imitate. This shows that very young birds can both hear and remember, and it would be very extraordinary if they could live for days and weeks in a nest and know nothing of its materials and the manner of its construction. During the time they are learning to fly and return often to the nest, they must be able to examine it inside and out in every detail, and as their daily search for food invariably leads them among the materials of which it is constructed, and among places similar to that in which it is placed, is it so very wonderful that when they want one themselves they should make one like it? Again, we always assume that because a nest appears to us delicately and artfully built, that it, therefore, requires much special knowledge and acquired skill (or their substitute, instinct) in the bird who builds it. We forget that it is formed twig by twig and fibre by fibre, rudely enough at first, but crevices and irregularities, which must seem huge gaps and chasms in the little eyes of the builders, are filled up by twigs and stalks pushed in by slender beak and active foot, and that the wool, feathers, or horsehair are laid thread by thread, so that the result seems a marvel of ingenuity to us, just as would the rudest Indian hut to a native of Brobdignag.

But look at civilised man! it is said; look at Grecian and Egyptian and Roman and Gothic and modern Architecture! What advance! what improvement! what refinements! This is what reason leads to, whereas birds remain for ever stationary. If, however, such advances as these are required to prove the effects of reason as contrasted with instinct, then all savage and many half-civilized tribes have no reason, but build instinctively quite as much as birds do.

Man ranges over the whole earth, and exists under the most varied conditions, leading necessarily to equally varied habits. He migrates—he makes wars and conquests—one race mingles with another—different customs are brought into contact—the habits of a migrating race are modified by the different circumstances of a new country. The civilized race which conquered Egypt must have developed its mode of building in a forest country where timber was abundant, for there is no possibility of the idea of cylindrical columns originating in a country destitute of trees. The pyramids might have been built by an indigenous race, but not the temples of El Uksor and Karnak. In Grecian architecture, almost every characteristic feature can be traced to an origin in wooden buildings. The columns, the architrave, the frieze, the fillets, the cantelevers, the form of the roof, all point to an origin in some

southern forest-clad country, and strikingly corroborate the view derived from philology, that Greece was colonised from north-western India. But to erect columns and span them with huge blocks of stone or marble is not an act of reason, but one of pure unreasoning imitation. The arch is the only true and reasonable mode of covering over wide spaces with stone, and, therefore, Grecian architecture, however exquisitely beautiful, is false in principle, and is by no means a good example of the application of reason to the art of building. And what do most of us do at the present day but imitate the buildings of those that have gone before us? We have not even been able to discover or develope any definite mode of building best suited for us. We have no characteristic national style, and to that extent are even below the birds, who have each their characteristic form of nest, exactly adapted to their wants and habits.

That excessive uniformity in the architecture of each species of bird which has been supposed to prove a nest-building instinct we may, therefore, fairly impute to the uniformity of the conditions under which each species lives. Their range is often very limited, and they very seldom permanently change their country so as to be placed in new conditions. When, however, new conditions do occur, they take advantage of them just as freely and wisely as man could do. The chimney and house-swallows are a standing proof of a change of habit since chimneys and houses were built, and in America this change has taken place within about three hundred years. Thread and worsted are now used in many nests instead of wool and horse-hair, and the jackdaw shows an affection for the church steeple which can hardly be explained by instinct. The Baltimore oriole uses all sorts of pieces of string, skeins of silk, or the gardener's bass, to weave into its fine pensile nest, instead of the single hairs and vegetable fibres it has painfully to seek in wilder regions, and Wilson believes that it improves in nest-building by practice—the older birds making the best nests. The purple martin of America takes possession of empty gourds or small boxes stuck up for its reception in almost every village and farm in America, and several of the American wrens will also build in cigar boxes, with a small hole cut in them, if placed in a suitable situation. The orchard oriole of the United States offers us an excellent example of a bird which modifies his nest according to circumstances. When it is built among firm and stiff branches it is very shallow, but when, as is often the case, it is suspended from the slender twigs of the weeping willow, it is made much deeper, so that when swayed about violently by the wind, the young may not tumble out. It has been observed also that the nests built in

the warm Southern states are much slighter and more porous in texture than those in the colder regions of the north. Our own house-sparrow equally well adapts himself to circumstances. When he builds in trees, as he, no doubt, always did originally, he constructs a well-made domed nest, perfectly fitted to protect his young ones; but when he can find a convenient hole in a building or among thatch, or in any well-sheltered place, he takes much less trouble, and forms a very loosely-built nest.

A curious example of a recent change of habits has occurred in Jamaica. Previous to 1854, the palm swift (*Tachornis phœnicobea*) inhabited exclusively the palm trees in a few districts in the island. A colony then established themselves in two cocoa nut palms in Spanish Town, and remained there till 1857, when one tree was blown down, and the other stripped of its foliage. Instead of now seeking out other palm trees, the swifts drove out the swallows who built in the Piazza of the House of Assembly, and took possession of it, building their nests on the tops of the end walls and at the angles formed by the beams and joists, a place which they continue to occupy in considerable numbers. It is remarked that here they form their nest with much less elaboration than when built in the palms, probably from being less exposed.

A fair consideration of all these facts will, I think, fully support the statement with which I commenced this article, and show that the mental faculties exhibited by birds in the construction of their nests are the same in kind as those manifested by mankind in the formation of their dwellings. These are, essentially, imitation, and a slow and partial adaptation to new conditions. To compare the work of birds with the highest manifestations of human art and science is totally beside the question. I do not maintain that birds are gifted with reasoning faculties at all approaching in variety and extent to those of man. I simply hold that the phenomena presented by their mode of building their nests, when fairly compared with those exhibited by the great mass of mankind in building their houses, indicate no essential difference in the kind or nature of the mental faculties employed. If instinct means anything, it means the capacity to perform some complex act without teaching or experience. It implies innate ideas of a very definite kind, and, if established, would overthrow Mr. Mill's sensationalism and all the modern philosophy of experience. That the existence of true instinct may be established in other ways is not improbable, but in the particular case of birds' nests, which is usually considered one of its strongholds, I cannot find a particle of evidence to show the existence of anything beyond those lower reasoning powers which animals are universally admitted to possess.

ON THE VARIOUS MODES OF PROPELLING VESSELS.

BY PROFESSOR M^C^GAULEY.

Some means of transport on water have been used from the earliest times; and as soon as the very rudest bark was invented, efficient modes of propelling it were devised. The principles applied to the propulsion of boats and ships have never varied much. That of the oar, which undoubtedly was the first contrivance employed, is also that of the paddle-wheel and the screw propeller. There is good reason to believe that the ancients used oars only for sculling; and the highest authorities on naval matters affirm that this is the best mode of employing them. We use them almost exclusively for rowing.

The wind offered a very convenient source of power, and, accordingly, navigators soon availed themselves of it. But the ancients placed more confidence in oars for the purposes of war; and hence, for either aggression or defence, they used biremes, triremes, quadriremes, etc., which have given antiquarians such trouble, and the nature of which is still involved in great uncertainty. The employment of oared gallies continued until a comparatively recent period; the Turks and Venetians retained them, long after sailing vessels of a very perfect form had been constructed, and we ourselves did not relinquish them until the reign of Henry VII.

Since my purpose is chiefly to speak of mechanical modes of propulsion, the consideration of sails, as a means of obtaining motion, is almost beside my purpose. The small cost at which power is obtained from the wind will, however, probably cause sailing vessels to continue always in use. The disuse of them as ships-of-war seriously affects our position as the masters of the sea.

Oars, made to revolve in a plane parallel to the sides of a vessel, afforded a paddle-wheel; and hence, in very early times, attempts were made to apply in that way the principle of the oar to the mechanical propulsion of ships. Paddle-wheels, similar to oars, were used by the Egyptians, the Romans, and the Carthaginians. But, until steam became applicable as a source of motion, no kind of mechanical propulsion could be equal to that obtained by means of oars. Hence the invention of the steam-engine, properly so called, and the practical adoption of the paddle-wheel were nearly simultaneous.

Paddle-wheels give rise to a great loss of power, on account of the way in which they enter and leave the water,

and great ingenuity has been devoted to the lessening or removal of this inconvenience. The advantage derived from feathering oars suggested the feathering of the float boards; but, besides that every contrivance for such a purpose must be complicated, and therefore both expensive and liable to accidents, most of the modes of feathering proposed are such as attain their object only when the vessel is at rest, the current produced by her motion not being taken into account by their inventors. The shock and consequent vibration caused by the paddles, when entering and leaving the water, has, however, been greatly lessened by breaking them into portions which successively enter and leave the water.

The unequal immersion of the paddle-wheels, on account of variations of the water line, is another serious inconvenience; and plans have been employed for raising and lowering them, so as to accommodate them to circumstances; but no contrivance for the purpose has been such as to merit its being adopted.

The short distance between the paddle shaft and the steam cylinders would give rise to an obliquity of the connecting-rod, with steam-engines of the ordinary form, that must cause a great loss of power. Hence marine engines are peculiar in their construction; their stroke is shorter, the position of the cylinders is varied according to circumstances; in some cases a connecting-rod is rendered unnecessary by the use of oscillating cylinders, and in others a piston-rod, by the use of trunk engines.

Instead of the paddle-wheel, attempts have been made to use, at each side of the vessel, a chain, having paddles attached to it, and passing round two wheels, its lower part being near the water line; but it was found that the friction of a heavy chain and the complication of the apparatus were fatal to it.

To get rid of the inconvenience arising from the paddles being too much or too little submerged, paddles entirely submerged have been tried. They were laid on their sides, so that their axes were vertical, one being at each side of the vessel, which was indented, so that only a portion of the paddles projected beyond its side. But, as may be supposed, the arrangement did not answer. On the whole, the paddle-wheel has retained, almost unchanged, the form given to it by its first inventors.

The screw propeller, which has nearly superseded the paddle-wheel, has been used for ages in China. The operation of sculling may have suggested it. Oars placed, at an angle, on an axis which was made to revolve in a plane parallel to the vessel's length, would be a screw propeller. It might have been suggested also by the windmill; for a windmill with

four vanes would be in reality a screw with four threads; and Bouquer, in a treatise published in 1747, mentions the application of revolving arms, like those of a windmill, to the propulsion of a vessel. It would be suggested, likewise, by the smoke-jack. Bramah, in 1785, patented the application, to the stern of a ship, of a wheel with inclined fans or wings, like those of a smoke-jack. He was the first to use a stuffing-box for connecting the screw with the prime mover within the vessel. In most of its early applications the screw was suspended at a distance from the stern, and motion was communicated to it by very clumsy means.

In its more perfect form, the screw propeller consists of threads or blades placed on an axis parallel to the keel, and forming segments of a helix or spiral. Its *pitch* is the distance in the direction of the axis between any one thread and the same thread at the point where, if continued, it would complete its next convolution. When there is but one screw, it can be fixed only at the bow or the stern. If at the former, it acts on water at rest, which increases its effect; but it throws water against the bow, which retards the vessel. If at the stern, to prevent interference with the rudder, it is placed in the dead wood, or that portion of the ship which is immediately behind the rudder. In 1768, Pancton suggested the use of one screw, either in the bow or the stern, or a screw at each side. But one of the earliest practical applications of the screw propeller was that by Bushnell, of Connecticut, in 1776. He employed one screw for raising or depressing, and another for propelling a submarine boat, which was intended for the fixing of torpedoes to the sides of hostile ships.

Perhaps no contrivance has afforded more occupation to ingenious minds than the screw propeller; it has been made of every conceivable form, and fixed to the vessel in every conceivable way. The number of patents to which it has given rise are counted with difficulty. It came into very general use soon after it had attracted the serious attention of experimentalists and projectors. But the Government were slow to adopt it. Smith, an Englishman, and an amateur, and Ericsson, a Swede, and an accomplished engineer, may be considered to have practically introduced it into use. Both of them endeavoured to secure the patronage of the Admiralty, but only Smith, whose experiments appear to have been more satisfactory, succeeded; and Ericsson left the country in disgust. Smith required gearing; Ericsson's professional resources enabled him to do without it. Smith used a single screw, consisting of one whole convolution, and also a double threaded screw, each thread of which was equal to half a convolution,—one-sixth of a convolution for each has since been found to

answer much better: and he placed the screw in the dead wood. Ericsson used two propellers, each consisting of short spiral plates, attached to the periphery of a broad thin hoop, which was fixed on arms radiating from the axle. Both propellers were behind the rudder, and revolved round a common centre, the shaft of one being within that of the other, and one being in front of the other. The hinder screw revolved with a greater velocity than the one in front of it, to enable it to act on water already in motion. But an equal advantage would be attained by the use of one screw of a larger diameter.

The slowness of the ordinary marine engine opposed a serious difficulty in the earlier attempts to apply the screw propeller. To overcome this, gearing was used, a very large wheel being made to work into a pinion fixed to the screw shaft. But there are great objections to such an arrangement. Independently of the intolerable noise, the teeth wear out rapidly, and are liable to sudden fracture with any violent strain of the sea. At present, a sufficiently rapid motion is obtained directly from the engines; nor is there any objection to this, since the supposition that the best speed for the piston is precisely that which is best for a canal horse, namely, 220 feet per minute, has for a considerable time been known to be a fallacy.

The screw shaft exerts an enormous thrust, in the place at which it abuts within the vessel, the whole force of impulsion being imparted there; the plate against which it works has been rendered white hot, although a stream of water was constantly flowing over it. Various means have been used to overcome this difficulty. Thus, in some cases, the end of the shaft is made to work against a disc of hardened steel, fixed eccentrically with reference to the shaft, and having a slow motion communicated to it; and in others, against rolling surfaces. In others, steel collars are placed on the end of the shaft, and being immersed in oil, are little liable to heat. Should, however, undue friction arise between the actual rubbing surfaces, new ones come into play, since all the collars are moveable. Other expedients also have been employed for the same purpose.

In the early days of the screw propeller, it was used only as an auxiliary to the sails. When not in use, if left in its ordinary position, it would retard the vessel, and other inconveniences would arise from it. To obviate these, means were used for raising it when desirable, and even for closing the aperture in the dead wood, which if left open must seriously interfere with the steering.

Centrifugal force disperses the water, causing the screw to throw it off in the form of a cone; it is far better that it should assume the shape of a cylindrical column. This has been

effected by setting the blades, not at right angles to the screw shaft, but in such a way that they point outwards from the stern. Their tendency is, then, to concentrate to a point the water thrown off by them; and centrifugal force corrects this, so as to give the water the form of a cylinder. Such an arrangement gives excellent results.

The action of the screw is greatly affected by adverse winds, currents, variation of the depths of immersion of the vessel, etc. But, as the velocity with which it revolves is almost invariable, whether the progress made is great or little, the consumption of power is, in nearly all cases, the same. It is otherwise with the paddle wheel, which in similar circumstances revolves more slowly. To meet this difficulty, means of altering the pitch of the screw blades, according to circumstances, have been devised; and of the plans proposed for the purpose, those of Bennet Woodcroft are the most remarkable for ingenuity and effectiveness.

To obviate the loss of power from portions of the blades effecting very little more than a dispersion of the water, the leading edge of the screw has in some instances been made nearly at right angles with the axis of the shaft, the pitch increasing slowly at first, and then rapidly, so that the trailing edge should stand on a line with the axis of the shaft. But the large amount of rubbing surface thus produced neutralizes the theoretically excellent qualities of this form of blade; and it has been greatly improved by cutting away a considerable amount of its leading edge near the periphery.

Not only has any interference of the screw with the steering been prevented, but it has been made a most effective auxiliary to, and even substitute for, the rudder. An application of the screw propeller in this way was suggested so early as 1800 by Shaler, and was carried into effect in 1803 by Dallery, who arranged it in such a way that it was turned with the rudder without its revolution being interfered with. Bennet Woodcroft, in 1851, devised a means of manœuvering the vessel, by causing the blades to feather, so as to pass edgeways through the water during one part of their revolution, and sideways during another. The application of the twin screw affords so excellent a steering apparatus, that by means of it a ship, even in still water, may be made almost to revolve on its centre. The twin screw has, besides, other advantages of so important a kind, that it is likely to be exclusively employed hereafter in the navy, and very generally in the mercantile marine. It affords a perfect substitute for the rudder, should the latter get out of order: if one screw is disabled by accident, there is still a propelling power: and it allows the vessel to be moved with equal velocity ahead or astern. It has been brought

forward at various times since the screw propeller first attracted attention, but its excellent qualities were not completely utilized until each screw was worked by separate engines. Even with these, which may be comparatively light and inexpensive, it secures great economy of space. A twin screw renders the navigation of the most difficult channels easy, and it is invaluable with a turret ship.

Of all the questions connected with the screw propeller, that of the *slip* is the most interesting and important. The screw propeller advances through the water—carrying the vessel along with it—in the same way as a metallic screw advances in a fixed solid nut. Were the nut of water in which the propeller works, as immovable as the fixed solid nut, the velocity of the ship and that of the screw would be equal. But, as the water *must*, to a certain extent, give way, the velocity of the ship must be less than that of the screw; and the difference of these velocities is termed the "positive slip." The latter is easily accounted for, to its full extent. Whatever may be the apparatus used for propulsion, any motion imparted to the water is so much lost, since none of it is communicated to the vessel. Fortunately this loss may be diminished; with the paddle-wheel, it is lessened by enlarging the float-boards; with the screw, by increasing its size, which may easily be made such as will render it superior to paddle-wheels. Care must be taken, however, that the additional friction produced does not counterbalance any advantage gained in this way.

A large amount of positive slip may be due to centrifugal force. When the vessel is retarded by adverse winds or currents, etc., the water may be so propelled centrifugally by the screw, that there will be an empty space at its centre. This may be prevented by deepening the screw in the water; the height of the column of fluid above it will then cause the particles to flow in, so as to rapidly fill the space which would otherwise be vacant.

The slip of the paddle-wheel cannot be decreased, like that of the screw, since the more it is enlarged, the more disadvantageous the angles at which the floats enter and leave the water. A paddle-wheel of small diameter, or a screw of small pitch, has a large power of traction, but with each the slip is considerable. Increasing the diameter of the screw, without altering the pitch, reduces the slip, without rendering it necessary to change the velocity of revolution. If the slip is judiciously decreased, the screw propeller becomes superior in efficiency to the paddle-wheel.

There is another variation between the velocity of the screw and the vessel, which, though it would seem impossible, undoubtedly exists. The vessel, in some cases, seems to go

faster than if the screw worked in a solid substance; and this excess of velocity of the vessel above that of the screw has been termed the "negative slip."

The negative slip has been accounted for in various ways, and is, perhaps, due to a variety of causes. It may, to some extent, be explained by a twisting of the blades which is consequent on the strain, and is equivalent to an increase of pitch. Screws with a fine pitch are more liable to it than those with a coarse. A more effective cause of the negative slip is perhaps found in the column of water that always follows a ship to fill up the space which is left vacant by the progress of the vessel. The forward motion of this current may more than counterbalance the positive slip which must, in every case, occur. More pressure, and therefore more power of resistance, is given to the water in which the screw is immersed, than are found in the surrounding water, also, by the mass of fluid which is elevated, at the stern, by the screw itself. The constant action of these two causes must always render the apparent less than the real positive slip.

The last mode of propulsion to which we shall direct the attention of the reader is the application of that reaction which is produced by fluid issuing from apertures. I shall say nothing of the numberless contrivances that have been constructed on the principle of ducks' feet—opening when intended to act on the water, and folding up when they were to be drawn in the opposite direction. Some of these are very ingenious, but all of them, if liable to no other objection, are of necessity so complicated, and so liable to injury, that their adoption would be out of the question.

The reaction produced by a stream of fluid is the source of motive power in Hero's engine, invented more than two thousand years ago at least, and of Barker's mill; and it is used in the rocket, and many other kinds of fire-work. Nature herself employs it as one of her sources of propulsive power; the stream of water emitted by the gills of fish acting as an auxiliary to the action of their fins. The application of this principle to the propulsion of vessels holds out peculiar advantages. Like the screw, it affords a means of aiding the rudder, and even rendering it unnecessary; it is very easily applied, the apparatus used with it being very simple, and less liable than even the screw to injury from external causes. Contrivances founded upon it were among the earliest which have been proposed as substitutes for the ordinary modes of propulsion; and, although they have been so long unsuccessful in the contest, there is some reason to suppose that they may yet supersede all others. They are beset, however, essentially with great difficulties, which the unskilfulness of the earlier experi-

mentalists rendered more serious than they naturally are. But it still remains a question whether or not these difficulties may be so far overcome that any contrivance of the kind can compete, not only in efficiency, but—which is of, at least, equal importance—in economy, with those already in use.

Toogood, in 1661, and after him Allen, in 1730, proposed to propel a vessel by means of a jet of water. Bernouilli, Linaker, Ruthven, and many others, at different periods, followed in the same path. With all such apparatus there must be a loss of power, on account of the necessary changes in the direction in which the fluid moves, and the great friction arising from the large amount of rubbing surface. The friction of fluids against solids is so great, that the advantage derived from a long sharp bow may be more than counterbalanced by the increased length of the vessel. The friction was enormously increased in the earlier contrivances by the extreme narrowness of the waterways. This led to another evil,—the smallness of the issuing current. The reaction of the water against which this current impinges can be great, and therefore a sufficient amount of resistance can be obtained, only when the issuing stream is considerable.

The principle of all such contrivances must be the same; the only difference consists in the mode of applying it. This has been extremely varied. In some instances pumps have been used; in others, a horizontal water wheel, or turbine, inclosed in a case, the water being drawn in generally at the bow or the bottom of the vessel, and emitted at the stern or the sides. In no department of practical science has the same thing been invented over and over again so often as in this.

Some interesting experiments are being made in America with a vessel, at each side of which the fluid is made to issue from pipes that are near the water-line, and are capable of being turned either towards the stern or the bow, so as to impel the vessel ahead or astern; or, if those at opposite sides are turned in opposite directions, so as to turn it round.

Still more important experiments are being made in this country with the "Waterwitch." This vessel is fitted with a turbine wheel, fourten and a half feet in diameter, working in a chamber which, ordinarily, has no connection with the rest of the vessel. The water enters from the bottom of the vessel, through gratings, and issues by means of two pipes, running the whole length of each side of the vessel, and so arranged that the fluid may escape from both orifices at the stern, or both at the bow, or from one at the bow and another at the stern, so as to turn the vessel on her centre. The issue of the water is regulated by sluices, which are under the control of an officer on deck, and can be worked without altering or

stopping the engines. Should the vessel leak, the water may be obtained from its hold instead of from the sea; and thus, by the very act of propulsion, the vessel will be kept afloat. Satisfactory velocities have been obtained by the "Waterwitch;" but the real question is that of economy, and regarding this no satisfactory data has yet been given by the experiments hitherto made. The only novelty in either the American vessel or the "Waterwitch" consists in ingenious combination of details which have long been known. The position of the exit tubes in the American experiment is evidently bad. They are exposed to injury, and the resisting medium is far inferior in efficiency to what it would be were they at some depth below the surface of the water.

Oars have been in a great degree superseded by sails, sails by paddle wheels, paddle wheels by the screw, and now the screw appears not unlikely to be set aside by a contrivance founded on a principle which is perhaps as old as most of them. How many valuable principles are allowed to remain for ages without practical application? The most important triumphs of science, those which have had the most effective influence on progress, are but developments of facts and principles that were long known.

SUN VIEWING AND DRAWING.

A READY METHOD FOR OBSERVING AND DEPICTING SOLAR PHENOMENA, BY MEANS OF PROJECTING THE SUN'S IMAGE UPON A SCREEN.

BY THE REV. FRED. HOWLETT, M.A., F.R.A.S.

(*With a Tinted Plate.*)

SELDOM has the writer met with an instance wherein very simple means and cheap appliances have, at least in a certain special line of astronomical observation, commanded better results, than the one which it is proposed to make the subject of the following paper. With respect, then, to the investigation of the sun it is encouraging to amateurs to know how much good work may be done by the aid of only a very moderate-sized telescope, in combination with a few simple and inexpensive accessories presently to be described.

Anyone possessing a good achromatic of not more than three inches aperture, who has a little dexterity with his pencil, and a little time at his disposal (all the better if it be at a somewhat early hour of the morning) shall be made acquainted with an easy method whereby he may deliberately and satisfactorily view, measure, and (if skill suffice) delineate most of

those interesting and grand solar phenomena of which he may have read, or seen depicted, in various works on physical astronomy.

We mean not to say, of course, but what very superior views of these phenomena may be obtained by means of those splendid instruments which are now to be found in the possession of not a few devoted lovers of astronomy, both amateur and professional; and we are aware, too, that it is only in the new, and fascinating, and important field of spectrum-analysis, specially in the hands of such sagacious observers as Kirchhoff, Huggins, Miller, Secchi, Donati, Alexander Herschel, and others—armed with special and variously-modified apparatus for the purpose—that our knowledge of the *chemical* constitution of the sun and other celestial lights can be promoted; but still it is not too much to say, that, with the sole exception of the much disputed "willow-leaf," or "rice-grain" shaped entities (asserted by Mr. Nasmyth and other high authorities to lie scattered in a nearly uniform but confused and interlacing stratum over the whole solar surface), a good achromatic telescope of only three inches aperture, and armed with a magnifying power of from 120 to 200 linear, will, if employed in the manner about to be explained, reveal nearly every solar phenomenon which up to the last ten or a dozen years was known to the scientific world.

And even as regards these last mentioned "entities" (what to call them exactly, we know not), which were described as being about from two to three seconds in length by about one-eighth or so of those measurements in breadth, though they certainly are not individually and separately to be seen by the aid of a telescope of only three inches aperture, yet may they possibly be recognized (if indeed they really exist) flaked together in those small, irregular, closely-approximated masses termed the "coarser granulations," or the "mottling" of the solar photosphere.

This mottling may be readily descried on days of steady definition by direct vision by any tolerable telescope (using of course some kind of darkening-glass in order to protect the eye from the glare and heat); but a much more distinct view of this remarkable structure of the sun's surface may be obtained by projecting the solar image on a screen, all due care being taken to procure the best and most perfect effect, by attending both to the best amount of magnification, and to the sufficient darkening of your chamber or observatory.

Many a reader, probably, of the INTELLECTUAL OBSERVER has seen the solar spots by ordinary direct vision through a telescope; and if the spots have been of a tolerable size, he will have been perhaps considerably interested in the sight. But,

unless exceptionally interested in the matter, he will soon probably be inclined to discontinue his observations (even though well disposed towards them), both on account of the difficulty with which the details of any but quite the larger spots can be descried by a merely ordinary instrument, the tediousness of keeping them in the field of view, the difficulty of recovering them, often, when lost, especially when use is being made of the higher powers; and lastly, the heat and glare with which the investigations of the glowing face of Father Sol are, under such circumstances, attended.

The writer remembers well the discouragements with which, in his novitiate, he had to struggle; whilst nevertheless (owing to the urbane encouragement of a world-honoured name in science)* he continued his solar record, with perhaps a moderate amount of success, but certainly an immoderate amount of *trouble*.

It had been long known, however, that an image of the sun could be thrown down the tube of the telescope upon a sheet of white paper (the focussing being duly attended to, and made a trifle longer than that required for direct vision), and that the existence of a solar spot could be readily made manifest by this method, as it is termed, of *projection*.

The writer had often noticed also that any specks of dust, or moisture, or what not, that might happen to be lying at the time upon the lenses of the eye-piece, were also faithfully though annoyingly projected likewise on the paper; though by rotating the eye-piece ever so little it was at once apparent which were solar and which mundane phenomena, inasmuch as the positions of the former were not at all affected by the rotation of the eye-piece, whilst the latter rapidly described portions of a circle, commensurate with the amount by which the eye-piece had been turned.

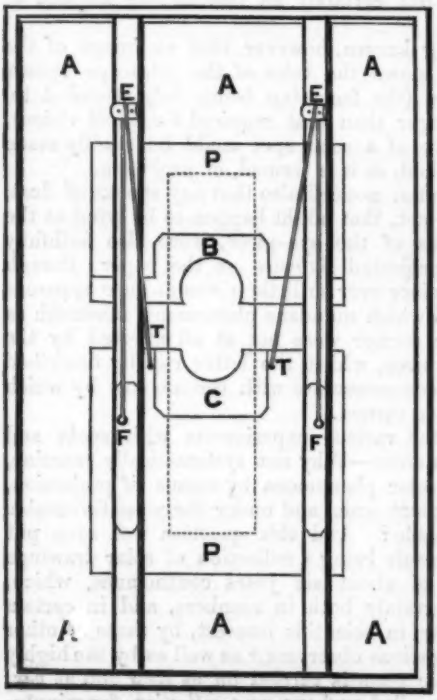
So at length after various experiments with spots and specks, the question arose—Why not systematically examine, measure, and depict solar phenomena by means of projection, on the largest convenient scale, and under the most favourable circumstances attainable? And this question was soon put into practice; the result being a collection of solar drawings and measurements, of about six years continuance, which, though exceeded certainly both in numbers, and in certain very important points, in scientific interest, by those of other indefatigable and sagacious observers,† as well as by the highly valuable photographic records carried on at Kew and at Ely, have not yet been excelled perhaps, as a *collection*, for minuteness of micrometric detail.

* Sir J. F. W. Herschel, Bart., of Collingwood, Hawkhurst.

† Viz., Schwabe, Wolff, Pastorff, and last, not least, Carrington.

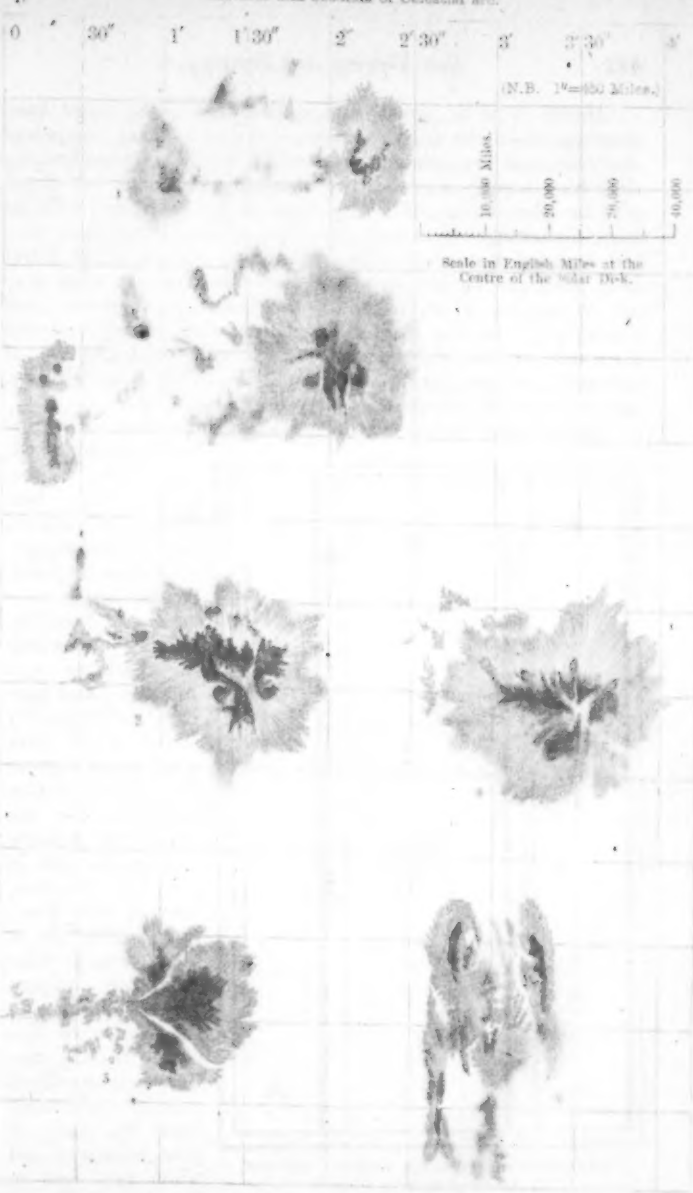
Hence it is of great importance that these large hand drawings should be diligently maintained by as many competent observers and draughtsmen as possible, until Heliophotography shall have happily succeeded in obtaining abundance of detail of solar phenomena, on a very much larger scale, and with far more distinctness than has yet been accomplished, save in a few isolated instances. The difficulties, indeed, which beset Heliophotography are immense; but who can say what may not at last be accomplished by the talent, perseverance, and liberality of De La Rue, Selwyn, and their coadjutors and assistants, in the comparatively new and wonderful art of celestial photography? Very much has been done already, and we sanguinely hope that more is yet to follow.

But we must now proceed to describe how these drawings were accomplished. And first, as regards the best method of projecting the solar image.



DARKENING SHUTTER, FOR VIEWING THE SUN BY PROJECTION ON A SCREEN.

Select a chamber having a window, if possible, looking towards the east as well as south; and having effectually closed up all other windows or sources of light, fasten neatly in the one remaining window a portable sort of wooden frame, covered with American cloth (A in Fig.), or some other substance impervious to light. In the centre of this cloth cut out a vertical aperture about an inch or so broader than the tube of your telescope, and about two feet in length. In front of this aperture, set up, by means of slender wooden bars,


Minutes and Seconds of Celestial arc.
0 ′ 30″ 1′ 1′30″ 2′ 2′30″ 3′ 3′30″ 4′
(N.B. 1″=650 Miles.)
10,000 Miles.
20,000
30,000
40,000
Scale in English Miles at the Centre of the Solar Disk.

VARIOUS SOLAR SPOTS.

As seen projected on a Screen; all to the same Scale; and as observed and measured by the aid only of 3 Inch aperture, Power 120 linear.

Fig. 1.—1864, Jan. 24, 2 p.m.
Fig. 2.—Jan. 25, 11 a.m.
Fig. 3.—Jan. 28, Noon.
Fig. 4.—Jan. 29, Noon.
Fig. 5.—1865, Feb. 17, Noon. A "bizarre" spot.
Fig. 6.—1865, Aug. 5, 8.30 a.m. A "grotesque" spot.

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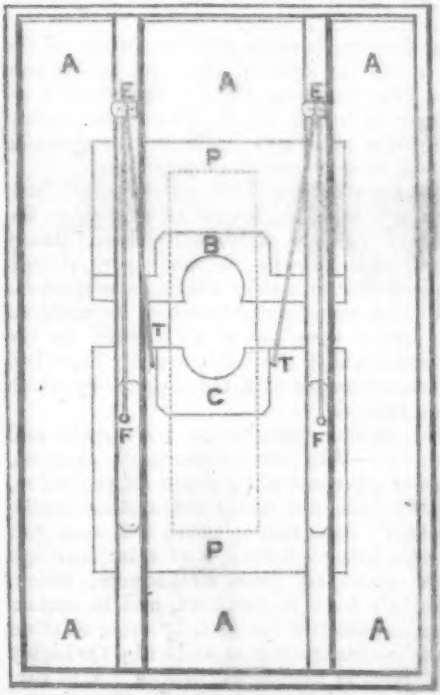

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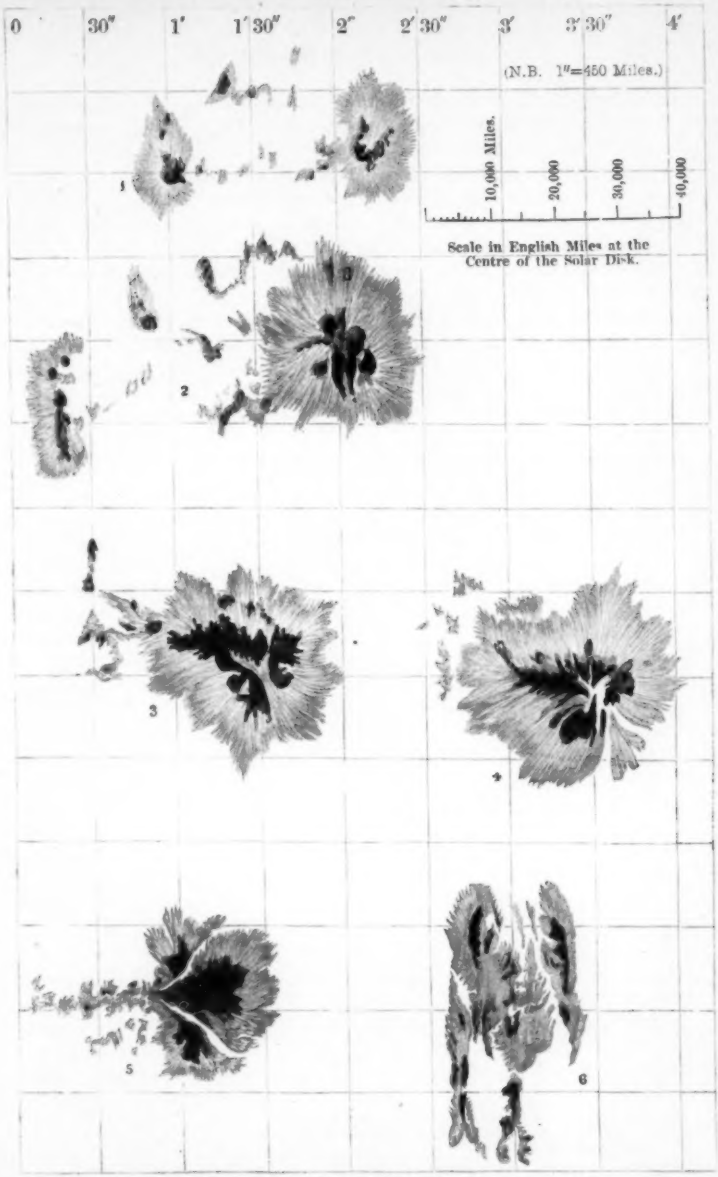

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two moveable pieces of stout pasteboard (P), or, rather, let us say one piece, cut *horizontally* into two. At the centre of this line of bisection cut out a semi-circular hole (B) from the upper piece of pasteboard, and a similar corresponding one (C) from the lower one; so that these two holes, when brought together, form a circle, which should be about two inches wider than the diameter of your tube. Round the edges of each of the semicircular orifices sew on (and glue likewise) a thickish piece of opaque vulcanized India-rubber (B and C), so that the elastic material may closely embrace your tube, but still allow your instrument a considerable range, both in altitude and azimuth. It will be far better, too, if the edge of the lower piece of the cardboard is arranged, so that when closed it may overlap the upper piece: otherwise it will be exceedingly difficult to prevent extraneous beams of light from entering through the interstices, and seriously interfering with the definition of the solar image on the screen. For this end, indeed, it will be necessary that the orifices in both the pieces of India-rubber should be cut rather semi-elliptical than semi-circular.

It will also be found extremely convenient to have pieces of tape (T T) fastened to the top of the lower piece of cardboard, and then passing upwards over, and behind two bottle-corks screwed down to the bars of wood at E, E, and then passing down again, and pinned, when requisite, to the two long, flat pieces of cork glued to the bars at F, F. By this means, after having directed your telescope upon the sun, you may at once effectually close your pieces of pasteboard, without any possibility of the lower piece slipping down again, which otherwise would frequently and annoyingly happen.

NOTE.—The place occupied by the large vertical hole in the American cloth is indicated in the Fig. by the coarsely-dotted rectangular line, except where its outline is represented, unbroken, between the two temporarily-separated pieces of pasteboard.

Next prepare your screen. The one employed by the writer is a sheet of "continuous drawing-paper," three and a half feet in length by nearly three feet in breadth, fastened down by a slight wooden frame upon a foundation of mill-board. This is placed on an easel, the legs of which are furnished with holes and pegs, so that the screen may be set at any height, as well as also placed at any requisite angle. Provide, also, a large T square, of light wood, by means of which you may at any moment see that the face of the screen is adjusted (and maintained) at right-angles to the line of collimation of the telescope—to the visual axis, that is, of the tube.

If now you draw apart the two semi-circular orifices above alluded to, you may readily direct your telescope upon the sun (without dazzling your eyes, as in the ordinary method whilst so doing), by so adjusting the tube, that the dark *shadow* cast by it upon the screen shall be a perfect circle. Then, having closely drawn the India-rubber round the telescope, and duly attended to the focussing, a perfectly defined and most pleasing image of the magnified solar-disc will exhibit itself, on a scale more or less enlarged, according to the power of the eye-piece employed, or the distance the screen is placed from the telescope. As a general rule, about one yard may be recommended as a convenient distance for producing an excellent effect with almost any eye-piece that the state of the atmosphere will admit of.

It will be found that, by shifting the tube slightly with the hand, the whole solar disc may be very rapidly and effectually scrutinized, with no more strain to the eyes than if it were being presented to you on a chart; and with a power of—say about sixty or eighty linear—the most minute solar spot, properly so called, that is capable of formation (for the writer believes they are never less than three seconds in length or breadth), will be more readily detected than by any other method; as also will any faculæ, mottling, or, in short, any other phenomena that may then be existing on the disc.*

The darker your chamber (your camera obscura, in fact) is, the more vivid and satisfactory are the results; and the writer will not easily forget the feelings with which he in this manner watched the progress of the solar eclipse of July 18th, 1860, along with his friends.

Drifting clouds frequently sweep by, to vary the scene, and occasionally an aërial hail or snow-storm, as mentioned by Mr. Browning in the number of the *Register* just alluded to; and the writer has more than once seen a distant flight of rooks pass slowly across the disc with wonderful distinctness, when the sun has been of a low altitude, and likewise, much more frequently, the rapid dash of starlings, which, very much closer at hand, frequent his church tower.

A transit of any of the inferior planets is also beautifully apparent by this method, as was witnessed by the Honourable Mrs. Ward, on November 12th, 1861, and agreeably recorded by that talented lady in an illustrated article in the very first number of the INTELLECTUAL OBSERVER.

* An instance of the facility of this method for detecting a very small spot is afforded by the fact, that, in the various accounts of the late eclipse of March 6th, 1867 (recorded in the *Astronomical Register* for the month following), almost all concur in stating that no spot was observed on the sun, whereas there most certainly was one spot visible about eight seconds in length.

Before proceeding to describe the method of *measuring* the spots, or other solar phenomena, it may be well to refer the reader to the Plate accompanying this paper, wherein may be seen micrometric drawings of various solar spots, the first four figures of which show the precise size and general appearance they presented on the screen (save that the attendant faculæ are omitted), and as they were then and there depicted. The two last figures were originally viewed and drawn under optical appliances of double power, and have been consequently reduced one half, linear, in order that the same scale might serve for all alike, viz., about 27,000 English miles to the inch; or, astronomically speaking, on this same scale one minute of celestial arc subtends one inch, and every second of this minute measures about 450 English miles near the centre of the disc, where the effects of foreshortening, produced by viewing objects on the surface of a sphere, are reduced to the minimum.

Sir John Herschel has alluded* to the bizarre, and even grotesque appearance assumed at times by the solar spots. And truly this circumstance with regard to them is occasionally not a little remarkable; and before describing more particularly the phenomena which frequently characterize an ordinary and well developed spot, we would call attention to Figs. 5 and 6 in the Plate, wherein Fig. 5 (which is not in the slightest degree exaggerated in form and symmetry) will probably be allowed to bear a very close resemblance to the petal of a geranium, or perhaps, picotee, or other flowering plant, according to fancy; whilst Fig. 6, affected, it is true, by a high degree of foreshortening, the most advanced border of the spot being not more than ten seconds from the preceding limb of the sun, may suggest to a lively imagination the belief that the uncouth gallinaceous bird, *Didus ineptus* (the Foolish Dodo), though said to be now extinct as a terrestrial species, is still to be reckoned among the fauna of the sun! By such comparisons, at any rate, may the mind be diverted occasionally, if only the whim be not allowed to warp the hand, whilst studiously transferring a representation of the solar spots from the screen to the sketch-book.

The writer has preferred to delineate this case of *Didus ineptus* as an instance of the grotesque, rather than another one still more remarkable, simply because it so happens that a photographic record of the occurrence of that *rara avis* was secured by Mr. John Titterton, of Ely, for Professor Selwyn, and to which, therefore, some of the readers of the INTELLECTUAL OBSERVER may be able, perhaps, to refer, though they must be reminded that the photographs represent the solar image and

* See Herschel on the Solar Spots, *Quarterly Journal of Science*, No. II., p. 224.

phenomena on only a very small scale. A yet more striking instance of both the bizarre and grotesque combined might have been adduced by the writer in the case of a magnificent group of spots which was thus alluded to in a paper read by him before the Royal Astronomical Society:*—"I have only one more subject to mention, and that is, that I hope some one else beside myself took notice of and depicted, or, better still, secured a photograph, of a most curious phantom-looking group of spots, which at 1 p.m. on the 4th January of this present year (1863) exhibited an appearance so wonderfully like a human skeleton that, in a less superstitious age than the nineteenth century, its portentous shape might easily have raised considerable apprehension in the minds of the multitude. Being Sunday when this was observed, and being much occupied with the more immediate duties of the day, I did not draw the group with micrometric correctness, but simply took a rough sketch of the phantom, which subtended about 5′ 40″ of arc of the solar surface, or 153,000 miles, and respecting which (as I observed lately to Admiral Manners†) I am really not aware that any love for the marvellous induced me to exaggerate in any degree the singularity of its proportions. Sheet 96 exhibits this group as it appeared, when much altered, on January 7th."

Having already alluded to the most convenient way of projecting the sun's image on the screen, we now proceed to explain how the spots, etc., may be accurately measured. Cause your optician to rule for you on a circular piece of glass a number of fine graduations, the $\frac{1}{100}$th part of an inch apart, each fifth and tenth line being of a different length, in order to assist the eye in their enumeration. Insert this between the anterior and posterior lenses of a Huygenian eye-piece of moderate power, say 80 linear. Direct your telescope upon the sun, and having so arranged it that the whole disc of the sun may be projected on the screen, count carefully the number of graduations that are seen to exactly occupy the solar diameter. A correct eye is requisite in order to judge precisely where any one diameter lies. By means of practice, however, this may soon be done with the greatest facility; and, inasmuch as the sun's disc is a perfect sphere, being neither oblate nor prolate in the slightest appreciable degree,‡

* See *Monthly Notices, Royal Astronomical Society*, vol. xxiii., p. 273, for Nov. 1863.

† The Foreign Secretary of the Royal Astronomical Society.

‡ This is the dictum of our present Astronomer Royal, Professor Airy; and Professor Brayley, in a very interesting article on the physical constitution of the sun, in the *Companion to the Almanack*, for 1864, says, that "the sun is the only body of the solar system having that figure, and the only known example of a perfect sphere in nature."

it matters not in which direction you measure your diameter, provided only the sun has risen some 18° or 20° above the horizon, and so escaped the distortion occasioned by refraction, which he will have done at such an altitude as that just mentioned, at any rate for any such purpose as we now are considering.

Next let us suppose that our observer has been examining the sun on any day of the year, say, if you choose, at the time of its mean apparent diameter, viz., about the first of April or first of October, and has ascertained that (as is the case with the writer) sixty-four graduations occupy the diameter of the projected image. Now the semi-diameter of the sun, at the epochs above mentioned, according to the tables given for every day of the year in the *Nautical Almanack* (the same as in Dietrichsen and Hannay's very useful compilation), is 16′ 2″, and, consequently, his mean total diameter is 32′ 4″, or 1924″. If now we divide 1924 by 64, this will of course award as nearly as possible 30″ as the value in celestial arc of each graduation, either as seen on the screen, or as applied directly to the sun or any heavenly body large enough to be measured by it.

Astronomers assure us, moreover, that the mean solar diameter is (according to the latest corrections) about 848,435 miles. Hence, if we divide this vast number of miles by sixty-four, we find that each graduation of 30″ subtends also 13,256 miles, or about 442 miles to each second of arc on the sun's surface. It is thus evident enough how any solar spot or facula, or other visible phenomena, may be readily measured. The telescope must simply be directed with the hand, so that any object that may be visible on the sun's surface may be brought up to the graduations seen projected also on the screen. Remembering, as we have explained above, how every graduation is equivalent to 30″, or (since one second = 442 miles) to thirteen thousand two hundred and fifty-six miles. It certainly was very accommodating that each division on the glass of $\frac{1}{800}$th of an inch should turn out to be equivalent to the neat amount of 30″, or half a minute precisely of arc; but so it was in the writer's experience, in combination with a Huygenian eye-piece magnifying 80 times linear.

It might be tedious to the reader to explain how an exact (or approximately exact) estimation of solar measurements was attained to in the case of higher eye-pieces not provided with graduated glasses, which, by the way, do not of course improve the definition of the instrument, though they do not very much interfere with it so long as they can be kept free from dirt, but especially from *moisture*, which last, however, seems to have a special aptitude for condensing upon the

interposed disc of glass, so that it will be found expedient frequently to wipe it. The Huygenian lenses themselves always remain remarkably free from any such condensation, the cause for the difference resulting, probably, from the different qualities of the glass itself.

It was observed above that the apparent size of any solar object visible on the screen was smaller or larger according to the distance which intervened between the screen and the eye-piece; and it was eventually found that when a power of 120 linear was employed, and when the screen was placed just five feet two inches from the eye-piece, one of the graduations of 30″ of arc, measured upon the screen exactly *one inch*. Hence, of course, half an inch upon the screen was equivalent to 15″ of arc, and this scale is, perhaps, as convenient and instructive as any, for the purpose of depicting solar phenomena, which may be comfortably copied at once off the screen upon transparent tracing paper, ruled across at regular intervals with faint lines, forming squares half an inch in size.* Lead pencils of the best quality should be employed in delineating the solar spots, the observer sitting in his camera obscura, with his back of course to the window shutter, and holding his tracing-paper somewhere or other within the cone of rays which diverge from the eye-piece, and which affords abundant illumination for the purpose in hand.

When using the ordinary Huygenian astronomical eye-piece in connexion with the screen, the projected solar image will be seen reversed, but *not* inverted as when the sun is viewed by direct vision. The disposition of the image is, however, otherwise affected by projection (it is turned inside out, as it were), and in order to correct all optical freaks and represent the phenomena as they would really appear in the *terrestrial* eye-piece, it will be necessary both to reverse and also invert the drawings on the tracing-paper, gumming them down (if it is wished to preserve them) upon uniformly-sized sheets of very pale stone-coloured drawing-paper, which can be bound up into volumes for reference.

The drawings are thus preserved from any possibility of being smudged, whilst at the same time the slightest mark of the pencil will be visible through the transparent tracing-paper. The faculæ—a very delicate feature to delineate—should be carefully executed in Chinese white with a camel's hair brush, avoiding a too abrupt and harsh outline. But inasmuch as the Chinese white is apt to be nearly obliterated when treated with the gum-arabic, the faculæ should

* Messrs. Droosten and Allen, of the Strand, London, makes up convenient-sized block-books of this tracing-paper, interleaved (as is necessary) with a white opaque paper, as a contrast to the pencil marks.

at first be only very faintly indicated with the lead pencil in the drawing, and then the Chinese white applied after the drawing has been gummed down. The object in using tinted paper as the foundation, is in order that the faculæ may be the more plainly apparent, by contrast.

But there is another point of much importance, which should be attended to by any one who is making a study of solar phenomena; and that is, a good approximation at least to the ever-varying apparent positions of the sun's poles and equator. Otherwise it would be impossible to determine whether any group of spots or other phenomena were situated in the sun's northern or southern hemisphere—a matter this of much interest. For it is by no means the case that the top or apparent zenith point of the sun's disc is always his north pole, or the bottom or nadir point is always his south pole. In fact, not only has the solar pole a proper inclination of his own of about 7° to the plane of the earth's ecliptic, but in consequence of the perspective effects produced partly by the earth's revolution in her orbit, but much more by her daily rotation on her own axis, the sun's poles (as referred to our horizon) are never the same for two minutes successively, save at about the hours of six a.m. and six p.m.; as the writer first discovered for himself, with no little interest. Or again, whilst at noon, in England, the sun's north pole in autumn lies many degrees to the *left* of his zenith, it lies just as far to the *right* of it at noon in spring. Thus it is always shifting. How then is this knotty point to be ascertained? How can we declare where his north and south poles lie, bathed in their *landmark-less* incandescent ocean of light?

With an equatoreally mounted instrument this would be a comparatively easy matter, but we are supposed now not to be in possession of such a luxury. But any ordinary telescope may be readily furnished with a thin slip of semi-transparent mother-of-pearl about the sixteenth part of an inch in width, graduated off into divisions the $\frac{1}{100}$th of an inch apart (every fifth and tenth graduation made more conspicuous, as before); and having also an exceedingly fine wire stretched across it in the middle at right angles, and the whole inserted within the focus of your terrestrial eye-piece. When viewing the sun therewith by direct vision, the position of any solar spot may be laid down with sufficient accuracy for most purposes, by throwing the fine wire exactly in a line with the zenith and nadir points of the sun for the time being, and then, whilst it is in this position, bringing up the mother-of-pearl to the centre of the spot, and counting how many graduations it lies to the right or left of the wire; then upon revolving your eye-piece in its screw about ninety degrees (and so bringing the wire into

a horizontal position), and bringing it up in that position to the spot, count how many graduations there are between the wire and either the zenith or nadir point of the sun, and lay your spot carefully down upon a ready-prepared circle drawn on paper by means of a rule, of which say every tenth of an inch shall be supposed to be the representative of each graduation on your strip of mother-of-pearl.

Three observations at least, on any three different days of one and the same spot must be made, taking care that they are as near as possible at the same hour and *minute*, otherwise the observations would be useless. A different method, however, is employed by the writer, which cannot here be described in detail. Now, after having secured three good observations on one circle on your paper, a line drawn through these three points will describe part of a circle of solar latitude; and a line drawn at right angles to this circle of latitude would (if drawn through the *centre* of the disc on paper) indicate the poles. Otherwise due allowance must be made for the effects of perspective upon the surface of a sphere, in order to judge of the positions of your solar latitude and longitude; bearing in mind, too, the fact that, owing to the sun's poles having a proper inclination of their own of about seven degrees to the plane of the earth's ecliptic, the north pole of the sun lies a little way within the top of the visible disc from July to December; and his south pole, in turn, a little way within the bottom of the disc from December to July.

About the middle of June and middle of December, the two poles lie just upon the very margin of the visible disc; and consequently parallels of latitude then appear to form with one another straight and parallel lines. At other times they appear to traverse the disc in more or less curved paths. By means also of reference to the tables of measurement of solar diameters in the *Nautical Almanack* for every day of the year, the amount of celestial arc expressed by each division of the mother-of-pearl may be very approximately obtained by observing how many of them occupy the diameter of the solar disc, and dividing the total number of seconds contained in a solar diameter thereby.

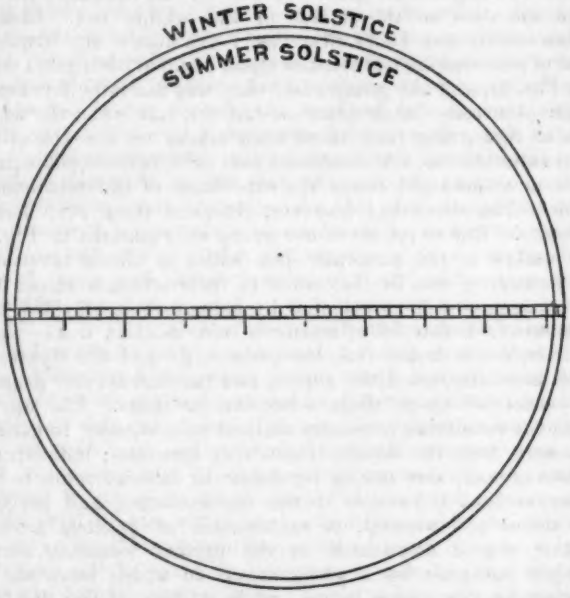
The writer finds that, with his achromatic of about three inches aperture, and with a terrestrial eye-piece, magnifying thirty times linear, each graduation subtends just about $42\frac{1}{3}$ seconds of celestial arc; and that at the period of aphelion, or our summer solstice, just 45 of them may be seen to span the solar diameter; whilst at perihelion, or our winter solstice, $46\frac{1}{4}$ of them are required.

The difference, which is very palpable, is shown in the cut.

We will now give a brief description of the phenomena

which commonly attend the life-history of a group of solar spots—observing, in passing, that usually they burst out more rapidly than they subside. Their formation commences generally with the appearance in the photosphere of one or more small specks, of only a few seconds in diameter, which sometimes are penumbral (grey) in their tint, and sometimes umbral, or blackish; implying consequently a greater or less amount of profundity—the deeper the blacker.

This stage is not shown in the Plate, because, in fact, the group had passed through it previously to its appearance upon the disc, which revolves, be it remembered, upon an axis, in



about twenty-five days. Fig. 1 was drawn when the leading spot of the group had advanced about 3½ minutes from the sun's limb or margin, and which would therefore be on the third day after its first entrance upon the visible disc. At this time several bright streaks of faculæ lay to the *left* of the group, which from some cause or other is usually the side they are wont to affect; though this rule is by no means invariable, for the faculæ frequently lie closely round the outer edge of a spot, and sometimes they may be seen scattered to the right as well as the left of a group.

At this stage of the formation of the group (Fig. 1) it may be observed how the umbræ or darker parts lie on the inner side of the penumbræ or lighter parts—a circumstance this which is highly characteristic of a group of spots, especially the more subordinate outlying ones, and also in its earlier stages, however it is to be accounted for, though it would seem to result from forces acting either from the centre, towards the circumference of the disturbed area, or *vice versâ*. At this time the total portion of the photosphere displaced by the various spots composing this group amounted to upwards of 400,000,000 square miles—an enormous area, indeed, as compared with aught terrestrial, but still far less extensive than is often the case on the surface of the mighty sun. Indeed, within twenty-one hours after Fig. 1 was drawn, the displacement of photosphere had reached about 778,000,000 square miles (see Fig. 2), and the group even then was not fully developed, which occurrence took place on Jan. 26, and when the whole area of this group (and there were others on the sun at the time) amounted to the enormous sum of 1,545,000,000 square miles, or about eight times the superficies of the terraqueous globe! The writer has, however, observed them even larger than this. But to return to our group as it appears in Fig. 2. The umbra of the principal spot (which is almost invariably the preceding one in the order of their advance across the disc) was now well surrounded by penumbra on all sides, and it moreover consisted of matter of two distinct tints—each, however, much darker than the penumbra—and the lighter of which two constituted the umbra, and the darkest and deepest the nuclei, of which there were two or three. The way in which the penumbra is usually marked with streaks, radiating, as it were, from the umbra, is now very apparent; indicating a current of some sort setting in, either the circumference to the centre, or from the centre to the circumference, and perhaps also either a down-rush or an up-rush of gaseous matter. That it was a down-rush on the present occasion seems strongly indicated by a phenomenon to which attention is directed by the writer in vol. xxvii., p. 185, of the *Monthly Notices* of the Royal Astronomical Society. He began to make a drawing of this spot at 11 a.m., Jan. 25, and observed at that time a small patch, of an almost umbral tint, at the upper edge of the penumbra (this patch may be seen in Fig. 2). He drew it, as it then appeared, exactly on the margin. But by the time he had finished the spot, as well as others on the disc, upon looking over his work, he found that the small patch was no longer at the margin. Believing he must have blundered, he altered it; but in an hour or so afterwards he observed that it was conspicuously removed from

the edge of the penumbra. He watched it for another hour, when his impressions were put beyond a doubt, and he called in a friend, a good observer, to corroborate the observation. Both himself and companion saw that the patch was distinctly drawing rapidly in towards the central umbra, and by three o'clock in the afternoon it had advanced two-thirds of the distance (= 12″) between the margin of the penumbra and the umbra, at the same time becoming more condensed and elongated in the direction of the usual striations on the penumbra.*

Fig. 3 shows the spot as it appeared about noon on January 28th. It was now beginning to diminish in area from what it was on the 26th, and the subordinate spots of the group were also beginning to break up; the photosphere, in other words, was beginning to re-assume its ascendancy; a sort of cicatrizing process, if we may so say, was setting in.

The spot was now, however, and had for three days previously been interesting, from the presence of a well-defined but ragged promontory or bridge, which floated over the umbra and divided it into different portions, as may so often be observed in the solar spots. At this time the promontory was not more luminous than the general penumbra to which it was attached, and it was consequently, in all probability floating at about the same level with it, and of the same temperature.

But on January 29th (see Fig. 4), not only had the promontory greatly altered in shape, but it was now as bright as the photosphere itself, with which indeed it seemed now in direct communication, by means of luminous streaks of considerable width, with which the penumbra had been invaded, showing either that the promontory of the previous day had risen up to the level of the photosphere and become equally luminous with it, or that it had sunk down altogether and melted away (as the writer and others have observed them to do), and that its position had been occupied in part by an indraught apparently of luminous matter from the vast circumambient ocean of photosphere. However this may have been, on January 30th the penumbra had again in turn inclosed and isolated the luminous matter in question; though it did not permanently hold it a prisoner; for by January 31st the photosphere had so energetically invaded the principal spot from both sides, as to completely divide it into two spots.

In short, the battle of the solar elements was decided; and on February 1st (the last time the writer was enabled to see the group), the spots were still further dispersing and diminishing; and had utterly disbanded themselves, and disappeared, ere

* In the Plate these striations are rendered somewhat too distinctly.

that portion of the sun by his rotation above alluded to, had again come round upon the disc.

But, finally, what are the sun spots—what the faculæ—what the photosphere—what, in short, as Mr. Carrington asks, is a sun? A congeries of difficulties to grapple with! But let us hope that by means of the rapid march of science in the departments of chemistry, electricity, spectrum analysis, and what not, the time is not far distant when many of these difficulties will be solved.

Much depends upon our being able satisfactorily to demonstrate (which seems more and more probable) that the laws which govern terrestrial phenomena are the same as those which prevail upon and within our great central luminary, modified very possibly by the existence of conditions, and even perhaps chemical elements peculiar to himself, as the source and dispenser of light, heat, and life, to the planetary worlds around him.

This, at least, seems certain—viz., that the solar spots are *negative* and not *positive*, if we may so say, in their character. That is, that they are areas on the solar surface, where either the photospheric matter has been swept aside, or where it has subsided and become invisible through a change in its temperature and molecular condition; and not actually dark, intervening clouds of condensed, metallic, or other vapour, obscuring simply the subjacent photosphere, as Kirchhoff would have it. Still less we maintain are they (as other theorizers rather than actual observers maintain), scoria, or other hardened masses, capable of being rent asunder, and thus again disclosing the photosphere below, in the shape of loops, bridges, or promontories.

The minute and careful observations multiplied by Nasmyth, Dawes, De La Rue, Lockyer, Chacornac, and the writer, place all such theories out of the question. It is far more probable, if not indeed certain, that the bridges, promontories, and specks of more or less brilliant matter, which all the above observers have distinctly seen to traverse the umbræ and even nuclei of solar spots, have either drifted away from the general mass of the surrounding photosphere, or are sometimes portions of photosphere which have only newly condensed and become visible; other pre-existing portions having, on the other hand, in their turn been seen to subside, apparently, or at any rate to dissolve and melt out of sight; and thus that the matter composing the photosphere may be visible or invisible, according as it is in the solid, liquid, or gaseous condition.

Professor Brayley considers it probable that in the photosphere, and probably the regions and strata lying below it, solid matter must be continually being produced, dissolved, and

reproduced by some such alternate process of refrigeration, breaking-up, and subsidence; and that it is from this more solid matter that the solar radiation of light and heat mainly proceeds. "An incandescent liquid or gas," as the President of the Royal Astronomical Society, too, observes, "such as we suppose the sun's atmosphere to consist of, will not give out light. We want, therefore, something floating in it, or where could the light come from?"

While on this subject of crystallization and subsidence, the writer would here state how, on more than one occasion, he has been reminded of such a state of things by a curious and interesting (if *not* very analogous) phenomenon presented to view in the boiling salt-pans at Droitwich in Worcestershire. The crystals of salt, varying much in form and size according to the temperature of the liquor out of which they are produced, first form on the surface of the hot brine, and then, after a while, begin to subside in patches not very unlike solar spots, or groups of spots. Other portions of the yet floating crust of salt may frequently be seen marked with bright blotches and reticulations, more nearly resembling solar faculæ, so far as mere form is concerned, than any other object he could readily call to mind. It is not, however, here intended that we are to consider the sun as a merely vast mineral salt bath; though sodium, at any rate, appears to be present there in sufficient abundance; and the mean density of his mass is just about the same as that of the brine!

A curious theory of the origin of solar spots, at present in increasing favour with some of our most philosophical observers* is, that they are produced by external planetary influences. Every twenty months or so, as they observe, the spots seem to assume the same sort of behaviour in their manner of forming and disappearing. With this circumstance is to be coupled the fact that every twenty months the planet Venus returns to the same position with reference to the earth, and that then, too, we see that, as any portion of the sun's surface retreats from the neighbourhood of Venus, the solar spots on that portion have a tendency to increase, attaining a maximum at the point furthest from Venus. And the inference they draw from this curious phenomenon—backed up by certain physical experiments in connection with heat, light, electricity, vaporization, pressure, etc., is that the sun is probably in such a sensitive molecular condition that its mass may experience wonderful changes from very small outward influences.

Now that the continuity of the outermost strata of the sun is, from some cause or other, subject to the most astonishingly extensive, and often rapid changes, is certain enough; as may

* Messrs. De La Rue, Balfour Stewart, Loewy, and others.

be sufficiently seen from the changes undergone in twenty-one hours in the group represented in Figs. 1 and 2 in the Plate. And the writer has often expressed his opinion that, along, perhaps, with other allied agencies, these changes are in some way connected with alterations in the magnetic conditions of the solar photosphere—an opinion with which the theory of planetary configurations and influences is quite in harmony; as also may be many other forces believed to be in operation on the solar surface, and probably also within the interior mass likewise.

In many respects, lastly, the forces they exhibit are as mighty in their operation as they are mysterious in their origin. We cannot doubt that, on the whole, they are necessary and beneficial to the several worlds which constitute the dominion of the sun; though they are occult and hidden in their nature; and may very possibly at times, and at the ordering of the Most High, rule over conditions of plague and scarcity, as well as of health and prosperity; for these circumstances, we can scarcely doubt, are in intimate connection with those terrestrial, magnetic, and atmospheric conditions over which the sun has been bidden to exercise his vast and ever-varying, and, generally, benignant influences.

VEGETABLE MONSTROSITIES AND RACES.

BY CH. NAUDIN.

(*From Comptes Rendus.*)

The discussion recently excited by MM. Dareste and Sanson, as to whether monstrosities in the animal kingdom can give rise to distinct races, recalls to my mind teratological facts, which appear to demonstrate that this may be the case in the vegetable world.

To avoid doubt, it may be well to explain that I use the word *monstrosity* in its ordinary botanical sense, that of notable departure from forms, that are typical, or reputed to be such. There is a marked distinction between monstrosities incompatible with reproduction, and those which do not impair the reproductive faculty. It is of the last only I have now to speak.

Well attested facts seem to me to place beyond doubt that considerable anomalies in the vegetable kingdom, that are usually classed amongst teratological facts, are faithfully transmitted from one generation to another, and become the

salient characters of new races. Horticultural practice might have furnished a great number of such instances if they had been collected, and verified by experiment; but I shall only cite a few, because they are the only ones which I know to have been examined scientifically, and they suffice to establish the principle of hereditary transmission of anamolies, by sexual propagation through an indefinite series of generations.

The first fact of this sort shall be borrowed from Professor Göppert, of Breslau. A poppy exhibited the curious anomaly of the transformation of part of its stamens into carpels, from whence resulted a crown of secondary capsules round the normal and central capsule, whose development was complete. Many of the little additional capsules contained, as well as the normal capsule, perfect seeds, capable of reproducing the plant. In 1849, Professor Göppert, hearing that a field of these monstrous poppies existed a few miles from Breslau, caused to be sown in the following year a considerable quantity of seed taken designedly from the normal capsules, and almost all the plants springing from this seed exhibited to a greater or less extent the monstrosity of the preceding generation. I do not insist upon these facts, because observation of them was not carried to a sufficient extent, and it might be found that the number of generations was not large enough to conclude from them the stability of the anomaly.

This doubt does not affect the following case:—Cultivators of ferns know that these plants are very subject to variation, and that some of them exhibit, even in a wild state, veritable monstrosities in the conformation of their leaves. These monstrosities are much sought after by collectors, and are regarded as excellencies, for which a high price was paid. Now they are easily and abundantly procured by simply growing spores taken from the abnormal part of a fertile frond. When the frond has remained in a normal state, the spores give rise to normal plants, while those from monstrous parts of the same frond are sure to produce plants affected by same kinds of change. During many years that this method of propagation has been employed, the transmission of the monstrosity has not been contradicted by experience.

Very considerable anomalies, which even more than those just cited, may be called monstrosities, are observed in three species of edible gourds, plants which have been cultivated from time immemorial, and which have never been found in a wild state. These anomalies have the peculiarity of characterising races that are sharply divided and very persistent, and which maintain themselves, in spite of change of locality and climate, and partially resist crossing with other races of the same species. The date of their origin is unknown, and we

cannot now tell under what influences they were formed; but as the species are all domestic, it is probable that some, if not all, have been produced by cultivation. Among them is a race of common gourds (*Cucurbita pepo*), in which the tendrils convert themselves into a sort of branches bearing leaves, flowers, and often fruits. There are also numerous races of the same species producing deformed fruits, warty, and parti-coloured, and which transmit their peculiarities with their seed so long as they are not modified by crossing.

A still more remarkable example is afforded by a small race of pumpkins, *C. maxima*, which we have received from China, and observed for many years in the Museum. It differs from the typical form of the species by the ovary, and the fruit being entirely free, and the tube of the calyx being reduced to a sort of disk (*plateau*), serving for the support of the carpels; notwithstanding, the complete adhesion of the ovary to the tube of the calyx is stated by authors to be an essential character of the family of the Cucurbitaceæ. This example shows how great the extent of variation may be, and what fixity they may acquire when once produced.

The next fact of which I have to speak is quite recent, and has already been brought before the Academy by Dr. Godron, Professor of Botany, at Nancy. In 1861 M. Godron found, in a crop of *Datura tatula*, a species with very spiny fruit, a single individual, in which the capsule was perfectly smooth, and unarmed. Seeds taken from this capsule gave, in 1862, a batch of plants, all of which reproduced the peculiarities of the individual from which they sprung. From their seed grew a third generation, similarly smooth, and in 1865 and 1866 I saw at the Museum the fourth and fifth generation of this new race, in all more than 100 individuals, not one of which manifested the least tendency to reproduce the spinous character of the species. Crossed with this last by M. Godron himself, the unarmed race produced mule plants, which in the succeeding generation returned to the spiny form, and the unarmed form, being, in fact, genuine hybrids, endowed with fertility. M. Godron, from these facts, refers to one species, the *Datura Stramonium*, *D. lævis* (of Bertoloni, not of Linnæus), and *D. Tatula*, three constant forms previously regarded as good species, and adding to it *D. Tatula inermis*, discovered by himself, and so to speak, born under his eyes. These four distinct forms have arisen by variation from a single type, not one of them wanting in any character assignable to true species.

Here a point presents itself, to which I would call the attention of all who believe in the mutability of specific forms, and who attribute the origin of actual species to simple modifica-

tions of more ancient species. Most of these observers admit that such modifications have been produced with exceeding slowness through insensible gradations, so that thousands of generations may have been required to transform one species into a neighbouring species. We know not what may have happened in the course of ages; but experience and observation teach us that at the actual epoch of anomalies, whether slight or profound, the alterations in what we, perhaps, arbitrarily, call *specific types*—the *monstrosities*, in fact, whether they are of a transitory and individual character, or whether they give rise to new races, persistent and uniform, through an indefinite number of individuals—are produced abruptly; and without any transitive forms between them and the normal form. A new race is born completely formed, and the first individual representing it exhibits the characters of the generations that will succeed if the variation is preserved. New modifications may be added to the first one, and occasion a subdivision into primary and secondary races; but these appear with the same suddenness as the first variation did. I am not defending the doctrine of evolution. I state merely that the biological phenomenon of one epoch do not justify, in any way, the hypothesis of an insensible degradation of ancient forms, and the necessity for millions of years in order to change the physiognomy of species. Judging from what we know, their transformations, if they have taken place, may have been effected in a much smaller lapse of time than is supposed. There may be alternations in the life of nature, and periods of immobility, apparent or real, may succeed other periods of rapid transformation, during which that which was previously exceptional and abnormal, becomes a portion of the regular order of things. And we must not forget that time is to us a succession of phenomena, and that whether the phenomena succeed each other quickly or slowly, it is all one for the doctrine of evolution. In either case the principle of continuity is not assailed.

ANCIENT MEN IN WIRTEMBERG.

The following paper is taken from the *Archives des Sciences*. It gives an account of recent discoveries of the remains of human industry in Wirtemberg as described by Professor Fraas.

In 1866, a mason of Schussenried, in Wirtemberg, was obliged to dig a long and deep channel to carry off some water that had been diverted by the drainage of an adjacent swamp. This work led to the discovery of a large quantity of fragments of bone and reindeer horn, and of implements wrought in flint and bone. Dr. Fraas had special diggings made to explore this deposit, and examined the results with great care. The ground cut through in these diggings showed the following succession, beginning at the bottom—a bed of erratic gravel, a layer of tuff containing terrestrial and fluviatile shells, identical with living species, and lastly, a thick bed of turf, forming the existing surface. The bones and wrought objects were discovered in a sort of excavation, or pocket, dug in the gravel and filled with moss and sand. The moss, which formed a thick layer between the gravel and the tuff, was in a state of such perfect preservation, that the species could be exactly determined by M. Schimper. They were *Hypnum sarmentosum* (Wahl.), *Hypnum aduncum*, var. *Grœnlandicum* (Hedwig), and *Hypnum fluitans*, var. *tenuissimum*. These mosses now live either in high latitudes or at considerable elevations above the sea-level, usually near the snow, or the nearly frozen water running from it. They belong to a very northern flora—about 70°,—and the *Hypnum sarmentosum*, in particular, to the limits of perpetual snow. The lower gravel is evidently erratic, and the marshy plain which the cutting traverses rests against a gravel-hill, which is nothing but an ancient moraine, and M. Desor states that in the vicinity of glaciers, hollows are found similar to this one containing various objects, and believed by Dr. Fraas to have been the rubbish hole of an ancient people, living at the time when the reindeer inhabited the neighbourhood.

All the bones found in the moss, which is kept wet by numerous springs, are completely preserved, while those in the gravel are entirely decomposed. The recent diggings exposed a prodigious quantity of bones and reindeer horns. The bones are all broken, having been split to extract their marrow; the horns were in great number, some whole, and belonging to young animals, others had been put to divers uses, and rejected as worn out. It is curious that the teeth had been carefully extracted from the jaws, for what purpose is un-

known. Except some fragments belonging to a species of ox, no bones of other ruminants were found, but there were some remains of the horse. The presence of the glutton, of a bear, differing from that of the caverns, and resembling the arctic bear, of the wolf, the polar fox, and the swan, and the absence of the dog, appears made out.

The fauna, like the flora, thus testifies to a northern climate, being composed of animals not fearing cold, and presenting no trace of that mixture observed elsewhere of northern animals with others belonging to temperate or southern regions. The remains of human industry consist principally of wrought flints (600 pieces), lance-points, arrow-heads, etc.; (no hatchets) some blocks (*nucléus*), together with needles, hooks, etc., of reindeer horn. Besides these, some rolled flints had evidently been used as hammers. Some flat stones, bearing traces of fire, and bits of charcoal testified also to the presence of man. There was no trace of pottery, nor of human bones. Nothing good, nothing whole, was thrown into this ditch; it was simply a receptacle for rubbish.

The fauna and the flora had, as we have seen, a peculiarly northern character; much more so than those of other stations of the reindeer epoch—that of Languedoc, for example. This remarkable fact gives importance to the discovery of Dr. Fraas. Must we conclude from it that the station of Schussenried belonged to a more ancient period? This is probable, but requires to be confirmed by further investigation. We must notice the apparent inferior civilization of the people to whom these relics belonged. They do not seem to have been acquainted with the potter's art, nor to have ornamented their implements with any sculpture.

Evidently, the station of Schussenried was posterior to the glacial epoch, properly so called—that is to say, to the time when the glacier of the Rhine formed moraines and accumulated gravels. But we may conclude from the presence of northern mosses, and from the character of the fauna, that the country had not been long cleared of ice when the people, who left these traces, established themselves in it. It is probable that fresh researches at other points may lead to the discovery of new stations, and fresh means of comparison, which may enable the age of that of Schussenried to be fixed.

MR. GRAHAM'S RECENT DISCOVERIES: — THE ABSORPTION AND DIALYTIC SEPARATION OF GASES BY COLLOID SEPTA:—THE OCCLUSION OF GASES.

In a series of papers communicated to the Royal Society, Mr. Graham has detailed his beautiful researches into the diffusion of gases. The subject of this paper is a brief account of his recent researches on the Absorption and Dialytic Separation of Gases by Colloid Septa.

It is necessary to remember that all gases when existing under circumstances in which they do not chemically combine, yet diffuse themselves through one another and form a uniform mixture, even though their specific gravities may be widely different, and they be kept externally at perfect rest; the law being that this tendency to diffuse varies in the inverse ratio of the square roots of their specific gravities. It must also be borne in mind that the same law regulates the diffusion of gases through septa possessing minute pores as when the gases communicate freely with each other.

Mr. Graham has shown how a mixture of gases may be changed in composition by the escape of the lighter and, therefore, more diffusible gas, this fact being well shown by passing an explosive mixture of one volume of oxygen and two volumes of hydrogen through the stem of a tobacco-pipe enclosed in an outer tube of glass, which is rendered vacuous, the hydrogen being more diffusive, streams through the porous walls so much faster than the oxygen that on issuing from the end of the pipe the mixture ceases to be explosive. But mixed gases must differ considerably in specific gravity in order to separate from one another to any great extent in their molecular passage into vacuum.

In his recent researches Mr. Graham has employed—firstly, the soft colloid, india-rubber; secondly, those metals to which a certain degree of colloid property might be imparted by means of heat.

When atmospheric air is separated from a vacuous space by a septum, or bag of india-rubber, some air passes through it into the vacuum. In observing the passage of air and gases into vacuum, the Torricellian vacuum was first employed. A plain glass tube, two millimetres in diameter and one metre in length, is closed at one end by a sheet of thin india-rubber strained over a porous plug of plaster of Paris, the tube is now filled with mercury and inverted, a vacuum being obtained into which air (or any gas allowed to play upon the disk of rubber) gradually penetrates, passing through the film and depressing the mercurial column in the

tube. The following numbers represent the velocity with which the rubber is penetrated by different gases in equal times :—

Nitrogen	1
Carbonic oxide	1·113
Atmospheric air	1·149
Marsh gas	2·148
Oxygen	2·55
Hydrogen	5·50
Carbonic acid	13·58

Air being a mechanical mixture of 21 per cent. of oxygen and 79 per cent. of nitrogen, the constituents of atmospheric air are carried through a film of rubber into a vacuum nearly in the same relative proportion as the same gases penetrate it singly, hence the composition of air "dialyzed" by the india-rubber septum is deducible by calculation—

Oxygen .	21	×	2·556	=	53·676	= 40·46
Nitrogen .	79	×	1	=	79·	= 59·54
						100·00

In the experiment with the Torricellian vacuum, air entering through the rubber was found to have the composition indicated by theory—40 per cent. oxygen and 60 per cent. nitrogen.

Dr. Sprengel's Mercurial Exhauster (Fig. 1) is now used instead of the Torricellian vacuum. It possesses the advantage of simultaneously maintaining the space vacuous, and delivering for examination any air entering through the septum.

The flow of mercury, from the funnel, A, through the fall tube, C B, is regulated by the clip which compresses the caoutchouc tube, C. The receiver to be exhausted is connected with the fall tube by a branch arm, X.

The descending stream of mercury draws the air

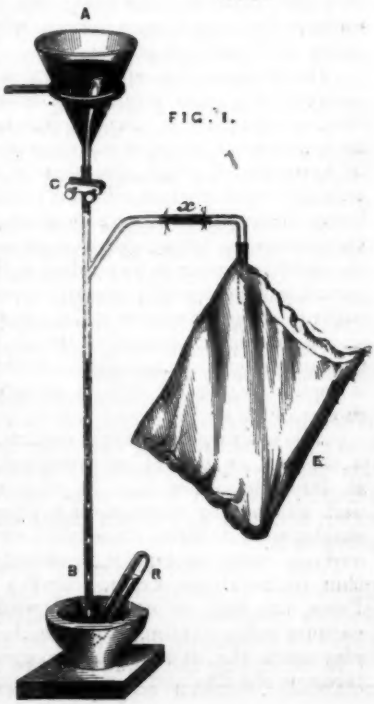


FIG. 1.

from the receiver and delivers it at E, a vacuum being ultimately produced.

E represents a bag of silk, varnished with india-rubber, lined with felted carpet.

After allowing sufficient time for the removal of the original air (representing the capacity of the bag), it will be found that the air *penetrating* the bag, and delivered into the tube, E, possesses the power of rekindling a glowing splinter of wood; analysis proving it to contain 40 per cent. of oxygen and 60 of nitrogen.

The constituents of atmospheric air will also pass through rubber into a space containing some other gas, as hydrogen or carbonic acid, at the same relative velocities with which they enter a vacuous space. Later experiments have also proved that air may be changed in composition by escaping under a pressure of two atmospheres through a rubber septum, the proportion of oxygen transmitted being slightly less than in the experiments with the vacuum.

This penetration of india-rubber by gases is not due to diffusion through actual pores; if it were, the lighter gases would pass through with the greater velocity; in the experiment with the rubber film, or bag, for instance, diffusion would favour the passage of nitrogen.

It will be seen, from the table given on page 453, that those gases which penetrate the rubber most readily are those most easily liquified by pressure, and also generally highly soluble in water.

Mr. Graham considers that the penetration of the gas through rubber is due to its previous absorption as a liquid in the soft, colloid substance of the india-rubber, the transmission being effected by the agency of *liquid*, and not gaseous diffusion. The rubber being wetted through by the liquified gas, the latter evaporates, and reappears on the other side of the membrane as a true gas.

There is, moreover, experimental proof of this *absorption*. When india-rubber is exposed to an atmosphere of carbonic acid gas, it takes up in one hour nearly its own volume, and this gas may be subsequently extracted by the action of the vacuum. Oxygen is twice as *soluble* in india-rubber as in water, and two and a half times more soluble in rubber than nitrogen is.

These experiments are of great physiological interest. Respiration is probably due to the liquid diffusion of gases through membranes. The air-bladder of fishes, especially those without a pneumatic duct, must be filled by the same agency.

In extending the inquiry to the passage of gases through metals, Mr. Graham employed tubes closed at one end, the

open end being placed in connection with Sprengel's Mercurial Exhauster. The metallic tubes were placed within porcelain tubes; the gas under examination was allowed to circulate through the annular space between the two, and the arrangement admitted the subsequent application of heat.

With a platinum tube, and *air* circulating outside it, the vacuum remained undisturbed, even when the temperature rose to a bright red heat: but when dry *hydrogen* was made to pass through the annular space, the platinum allowed the hydrogen to pass through into the vacuum, as soon as, but not until, the metal was raised to a red heat. In seven minutes the Sprengel tube delivered 15·47 cubic centimetres of gas, of which 15·27 cubic centimetres were pure hydrogen. The platinum tube employed was 1·1 millimetre in thickness, with an internal diameter of 12 millimetres.

The surface actually heated was 200 millimetres (8 inches). The rate of passage of the hydrogen was therefore 489·2 cubic centimetres, through a *square metre* of platinum 1·1 millimetres thick in one minute. The passage of other gases through the same tube was next examined, the experiments being conducted in exactly the same way, the metal being heated to bright redness. The most interesting fact developed itself, that while hydrogen could penetrate at the above rate, the following gases were incapable of passing, even to the extent of 0·2 cubic centimetres in one hour:—Oxygen, nitrogen, chlorine, hydrochloric acid, steam, carbonic acid, carbonic oxide, marsh gas, olefiant gas, hydrosulphuric acid, and ammonia.

It was, however, with a tube of palladium that the most remarkable results were obtained, that metal permitting the permeation of hydrogen with far greater facility than platinum, and at a temperature short of redness. The closed palladium tube remained perfectly tight when connected with the Mercurial Exhauster, with air (or carbonic acid) outside the tube, both at the ordinary temperature, and at a temperature near low redness.

When dry hydrogen was allowed to circulate in the annular space, none passed through in three hours at a temperature of 100° C., but when the temperature was raised to 240° C., the hydrogen began to come through at a gradually increasing rate, until 265° C. was reached, when the exhauster delivered 11·2 cubic centimetres in five minutes, or 423 cubic centimetres for a *square metre* of palladium one millimetre thick.

It is interesting to compare the passage of hydrogen through the palladium with the penetration of the same gas into vacuum through a septum of india-rubber. The palladium, one millimetre in thickness, was seventy times the thickness of the rubber sheet.

The comparison follows, penetration of hydrogen through a square metre of the rubber in one minute, at a temperature of 20° C.=127 cubic centimetres, through the palladium=423 cubic centimetres, at a temperature of 265° C.

It has been shown that oxygen could be partially separated from atmospheric air by the septum of india-rubber, while platinum and palladium only permit hydrogen to pass, apparently to the exclusion of every other gas. Therefore when the palladium tube was heated to 270° C. in an atmosphere of coal gas consisting of a mixture of 45 per cent. marsh gas, with 40 per cent. free hydrogen, the gas penetrating the metal and delivered by the mercurial exhauster contained no trace of carbon compound, but was *pure hydrogen*.

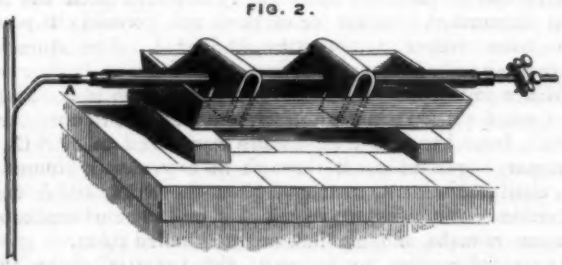
It is now necessary to consider the nature of these transmissions in the case of the rubber and metal respectively.

In the passage of gas through the india-rubber, it has been shown that the colloid substance possessed the power of absorbing the gas. Is the penetration of the platinum due to the same cause?

The following experiments were devised in order to determine this:—

The metal was first carefully cleaned by washing in alkali, and subsequently with distilled water; it was then introduced into a porcelain tube glazed both inside and out, and provided with corks well covered with fused gutta percha, each cork was fitted with a fine quill tube. The one quill tube, A, being connected with the mercurial exhauster, the other being then closed. It is evident, therefore, that the apparatus afforded a means of heating the metal in vacuo, and of transferring any gas that might be distilled over.

FIG. 2.



Wire of fused platinum weighing 200 grammes was heated to bright redness, and allowed to cool slowly in a stream of pure and dry hydrogen.

The same wire on distillation in vacuo gave 2·12 cubic

centimetres of gas, of which 1·93 proved to be pure hydrogen.

The weight of the metal being divided by its specific gravity (201÷21·5) gives the volume of the metal=9·34 cubic centimetres; hence the one volume of platinum held (the gas being measured cold), 0·207 volumes of hydrogen. It must be admitted, therefore, that platinum has a power to absorb hydrogen at a red heat, and to retain it for an indefinite period, to this power Mr. Graham has given the name of *occlusion* (a shutting up) of hydrogen by the metal.

Hammered platinum has a much higher absorbing or "occluding" power than the fused metal, probably owing to a mechanical difference in the texture, a specimen, in the form of tube, occluded 2·8 times its volume of hydrogen; the same platinum again charged with hydrogen was sealed up in a glass tube, after two months it gave on distillation in vacuo 2·28 times its volume of gas, tending to prove that the hydrogen had been retained by the platinum without loss.

It has already been stated that the transmission of hydrogen through palladium was far more striking than in the case of platinum, the permeation taking place at a far lower temperature. The results given by the occlusion of hydrogen by this metal were also most remarkable. A specimen of foil rolled from wrought palladium, weighing 1·58 grammes, was exposed to hydrogen, at a temperature between 90° and 78° C. for three hours, and then allowed to cool slowly in a stream of the gas. The metal was then transferred to a glass tube, which was exhausted in the usual way, and on being heated with a gas flame the palladium gave off gas in a continuous stream for twelve minutes, when the evolution ceased. The volume of gas amounted to 85·56 cubic centimetres. The palladium having occluded 643·3 times its volume of hydrogen. As in the case of the platinum the *melted* metal does not possess the power to the same degree as the wrought metal. The specimen examined absorbed about 347 times its volume of hydrogen.

Each metal exerts a selective power for gases. Copper wire occludes 0.306 times its volume of hydrogen. Gold cornets* from the refuse of assays were examined without preliminary treatment, 93 grammes, having a volume of 4.83 cubic centimetres, gave, on heating in vacuo, 10.25 cubic centimetres of gas, which consisted principally of carbonic oxide. The same cornets, though they never assumed so much gas as they acquired in the muffle, still occluded 0.33 times their volume of carbonic oxide, and 0.48 times their volume of hydrogen.

* When the button of gold is removed from the assay furnace it is rolled into a riband and twisted into a flat spiral, to which the name of "cornet" is given.

Heated in air they absorbed 0.2 times their volume of gas, which was principally nitrogen, showing a remarkable indifference to oxygen. Silver was also examined, one specimen occluded in successive experiments 8.05 and 7.47 times its volume of oxygen, without any visible tarnish.

It was with iron that results of the greatest commercial, as well as scientific interest, were obtained. Iron possesses the power to occlude hydrogen, but carbonic oxide is taken up far more largely than hydrogen, by slowly cooling the metal, from a dull red heat. In the process of converting iron into steel by cementation, the bars of malleable iron are imbedded in charcoal, and heated to redness in chests of fire-brick. The cause of the penetration of carbon into the centre of the mass of iron has always been obscure.

As Mr. Graham observes, the occlusion of carbonic oxide by the metal at a low red heat appears to be the first and necessary step in the process of "acieration." The gas appears to abandon half its carbon to the iron, when the temperature is afterwards raised to a considerably higher degree. The process of cementation being thus divided into two distinct stages, the first at a low temperature, during which the carbonic oxide is occluded, the second at a higher temperature, in which carbon is separated.

Lastly, in all these experiments, the metal was first heated in vacuo, in order to remove any gases that might have been occluded in the process of its manufacture.

The natural gases of commercial wrought iron appear to be a mixture of hydrogen and carbonic oxide. It became, therefore, a point of great interest to examine the natural gases of meteoric iron. A notice of the facts having appeared in a late number, it is only necessary to state that the iron of the Lenarto meteorite gave out on heating in vacuo 2.8 times its volume of gas; of which eighty-five per cent. was hydrogen. Thus a fall of meteoric iron on the earth brings to us the same gas that has been discovered by Messrs. Huggins and Miller to exist in the atmosphere of many of the fixed stars.

CLUSTERS AND NEBULÆ.—SOUTHERN OBJECTS.—DOUBLE STARS.—OCCULTATION.

BY THE REV. T. W. WEBB, A.M., F.R.A.S.

If we suppose a line drawn from *Arcturus* to *a Ophiuchi*, and from near its centre drop a perpendicular to it for some distance, the latter will hit a 2 mag. star, the brightest in a considerable area, *a Serpentis*, which may be also identified from its lying in a straight line between two 3 mag. attendants, the one *n p* being δ (which is double, No. 26 of our list, Int. Obs. ii., 56), the other *s f* (which is nearer *a*) being ε. From this last star we must run out a line at something less than a right angle—say 80°—with that joining ε and δ, and of about equal length; if we then sweep over the region where it ends, we shall find a 5 mag. star, 5 *Serpentis*, which should be visible to a keen sight, but will at any rate be conspicuous with slight optical aid: just *n p*, the finder will show us a patch of haze, and the telescope will reveal—

44. *The Great Cluster in Libra.* Gen. Cat. 4083—M 5. Smyth calls this a most beautiful cluster of minute stars, greatly compressed in the centre, with outliers in all directions. In his achromatic of $5\frac{9}{10}$ inch aperture it was a superb object, with a bright central blaze, exceeding even M 3 (No. 41 in our last number) in concentration. The progress of optical power is well illustrated by the fact that M., the discoverer, said of it, in 1764, "je me suis assuré qu'elle ne contient aucune étoile," and H with the 40f. reflector, in 1791, counted about 200 in it, though they were undistinguishable from compression in the centre. H. with less aperture, but finer definition, describes it as "a most magnificent, excessively compressed cluster of a globular character. Stars 11—15 mag. Diam. in R.A.=10 sec. of time: the more condensed part projected on [seen through?] a loose irregular ground of stars. The condensation is progressive up to the centre, where the stars run together into a blaze, or like a snowball; the scattered stars occupy nearly the whole field. The neighbourhood is poor in stars." He has also given a beautiful figure, well exhibiting the general character, especially as to the varying sizes of the stars. With my $9\frac{1}{4}$ inch speculum I found it a very bright and beautiful object, the central body of minute stars being barely resolved, while many larger ones are scattered irregularly around and across, or throughout, the glittering accumulation. I noticed, however, some features which do not appear either in the description or drawing of H. The brightest part of the condensed mass lies decidedly *n p* its general centre of

figure; the largest star in that portion is *s f* the centre; and *n* of the blaze, and beyond a comparatively vacant interval, there is a curved line formed by several of the brighter stars, pointing a little inwards at its *p* extremity, as though it were a portion of a large spiral. These are indeed minutiæ. But such minutiæ not merely form the distinctive character of the object, but may be important in process of time as tests of the stability of a system, of whose real nature we know much less than we infer. It may be to this string of stars that the E. of Rosse alludes, in including the cluster among those in the exterior stars of which "there appears to be a tendency to an arrangement in curved branches, which cannot well be unreal or accidental." Supposing the impression to be as accurate as it is strong, the brighter stars, of which there are many scattered in a surrounding low-power field, are not accidentally projected in front of and around the mass, but form a constituent part of it; and if so, we have evidence of the combination of widely different magnitudes in one system, more distinct than even in the case of M 3, described in our last number. With a power of 450, which for such an object overpresses the light of 9¼ in. of silver-on-glass, it is but a turbid speck. But words cannot express the magnificence of the spectacle could we be transported to the corresponding, or a still less distance, till that "stellar swarm" was expanded into a glittering mass of hundreds of suns of various sizes, occupying a widely extended region of the sky. Such an object would surely force from the least attentive the exclamation which may well be drawn out even by the feeble approximation to such a sight in a competent telescope, "Great and marvellous are Thy works, O Lord God Almighty!"

The boundaries of *Libra* and *Serpens* are strangely tortuous and intermixed in this region; in fact this cluster never should have belonged to the former, and has been boldly thrown out of it by Argelander in his *Uranometria*. It may be worthy of notice that 5 *Serpentis*, the guide-star to the cluster, is marked by him as of 5 mag., while he gives only 6 mag. to 10 *Serpentis*, a star intervening with a southward bearing between it and *e*, but the two appear to me, with a beautiful field-glass, of the same brightness, as they are also marked in the S. D. U. K. map. The remark acquires value from Argelander's high reputation for accuracy; and the stars may deserve watching.

By way of an instructive comparison with this and similar objects in respect of the varying sizes of the stellar components—a point deserving of more consideration than it has received—we will add Sir John Herschel's account of a glorious cluster in the S. hemisphere. We have another motive in doing this—that of gratifying the laudable anxiety of some of

our colonial friends to become better acquainted with the wonders of their peculiar sky. Our readers at home will readily forgive an occasional addition of this kind to our previous plan, both as respects clusters and nebulæ, and double stars, especially as it is from description alone that the majority of them can ever acquire any idea of the riches of a part of the heavens which never rises in these latitudes; and to those once familiarized by personal observation with a class of objects, the verbal account of others of a similar character is neither uninstructive nor uninteresting. These southern additions will be indicated by Roman instead of Arabic numerals in our lists. We begin, then, with

(i.) *The Great Globular Cluster, ω Centauri.* Gen. Cat. 3531. R.A. xiii. h. 18m. D.S. 46° 35′. Of this H. says, that it is beyond all comparison the richest and largest object of the kind in the heavens. Its diameter (in his 18¼ inch mirror) is full 20′, or ⅔ that of the moon: the stars are literally innumerable, and there must be thousands of them, for it is very conspicuous to the naked eye as a dim cometic-looking star of 4⅔ to 5 mag.; but as the total area is very considerable (not less than a quarter of a square degree), the same quantity of light concentred in a single point would very probably exceed that of a 3 mag. star. The whole mass, which is by gentlest degrees much brighter in the middle, is clearly resolved into stars; these, on a general view, appeared singularly equal, and distributed with the most exact equality, the condensation being that of a sphere equally filled. On more attentive looking, however, he perceived that there were two sizes among them, 12 and 13 mag., without greater or less, and that the larger stars formed rings like lace-work over the mass. One of these rings, 1½′ in diameter, was so marked as to give the appearance of comparative darkness in the centre, like an oval hole divided into a double opening by a bridge of stars. "Altogether," as H. concludes his description, "this object is truly astonishing;" and his figure well corresponds with these words. It is to be regretted that from its position, though it is above the horizon of Spain, Italy, or Greece, it does not attain a meridian altitude of 10° till we reach the latitude of Damascus. Beyond this limit, however, or, perhaps, even before it is attained, in those pellucid skies, it must begin to exhibit its marvellous aspect. An attempt at allineation on the part of one who has never seen the objects may not unfitly excite a smile, but we will attempt to mark its place by saying that it lies a trifle *s* of a line from *α* through *ζ Lupi*, two very solitary and it may be presumed conspicuous 3 mag. stars nearly on the same parallel, and at about half their distance from the latter.

From a great many occasional inspections of this superb cluster, H. inclined to attribute the appearance of two sizes of stars to "little groups and knots of the smaller size lying so nearly in the same visual line as to run together by the aberrations of the eye and telescope: this explanation of an appearance often noticed in the descriptions of such clusters is corroborated in the present instance by the distribution of these apparently larger stars in rings or mesh-like patterns, chiefly about the centre, where the stars are most crowded." This ingenious supposition does not, however, quite account for the equality in size of the larger stars, which, as necessarily composed of groups varying in number, would, it might be expected, show more variety in brightness also. But however correct it may be in this or other instances, it is evidently not applicable to cases such as we have recently described, M 3, and especially M 5, in which the larger stars occur as frequently among the stragglers, where such coincidences must of necessity be far less common. Computation, or even graphical projection, would show what, on the hypothesis of visual coincidence, ought to be the ratio of increase in such combinations as we approach the centre of the mass: the preliminary assumption of symmetry, whether in equidistant arrangement or progressive condensation, would, of course, be seldom fulfilled; but the effect of irregularities would be limited, and might be allowed for within certain bounds of probability. And by working steadily on in this direction we might approximate more nearly to a true idea of the internal structure.

To those possessed of adequate instruments—to which must be added, a knowledge of the effects of perspective—the investigation of the mode of combination and distribution in these grand and mysterious aggregations may be pointed out as an interesting pursuit. We seem already to be upon the trace of some general laws. H. has taught us to look for larger and ruddier stars in a central position; the Earl of Rosse has pointed out a tendency to curvature in the outlying branches, and the occasional presence of dark rifts or "lanes;" and it may fairly be expected that persevering examination, careful drawing, and systematic comparison of the principal clusters, may lead to the detection of other peculiarities, of some significance it may be, at least, to astronomers as yet unborn. However advanced we may deem ourselves—as we unquestionably are—in some, and those very important respects, in others we must even now be satisfied with laying foundations. The "adhuc plus ultra est" of Kepler will never be out of date. As it has been given to us to raise a noble superstructure on the labours of earlier workers, so we must be content to do in turn the same preliminary office for future generalizers

of collected facts. And where movement is imperceptibly tardy, observation can but wait upon it with corresponding patience. In these matters we have reason to believe, though not to be absolutely confident, that motion is all but imperceptible; but we must recollect what has happened to the primitive belief as to the immobility of the so-called Fixed Stars. Change of place in the collective body, which has already been suspected by great observers, and which would be in harmony with the "proper motions" of unnumbered solitary or binary stars, could only be dealt with in the majority of cases by appropriate methods of measurement; the graduated instruments of observatories would, of course, be always applicable, but perhaps seldom necessary, if Alvan Clark's ingenious, beautiful, and far less costly micrometer for measuring large distances (*Monthly Notices*, xix. 324) were brought into use. The range of this apparatus being about a degree, the cases would not be many in which a cluster could not be compared, both in position and distance, with several surrounding stars; and though such comparisons would be singly of little weight, their precariousness would disappear under a multitude of repetitions, while the employment, where practicable, of several stars in different bearings, would detect any material error arising from proper motion amongst them. But besides this, each cluster possessing sufficiently salient points should be watched for a much more interesting phenomenon—internal change. This is so far less probable than spatial movement, as it is unsupported by any other except the most general analogy; but what, of such things, ought to be pronounced impossible? Some great authorities would not so pronounce it. And some clusters are well enough marked to show it, by the distinctness and individuality, or marked arrangement of their brighter components.

Another noticeable feature in stellar clusters would be difference of colour in different parts. Such a variation is not without an analogy, which, however slight and distant, should no more be neglected in an investigation where we have so little to aid us, than some faint foot-print would be disregarded by the traveller in a pathless desert. Notwithstanding what may at first appear the fortuitous dispersion of colour among insulated stars, I have been led to notice so striking a prevalence of an uniform tint in some regions, as to believe that a general and careful review of the whole heavens, with regard to this point, would be desirable. Not only would this be interesting in regard to possible change, but it might lead to some result as to the mode of distribution; and I have been gratified by observing that the idea is corroborated by the spectrometric researches of Secchi, who has detected a preva-

lence of green light among the stars of Orion. But whatever may become of this attempt at analogy—if such it may be termed—the remark of H., already referred to, as to the frequent occurrence of a ruddy star in the midst of a group or cluster, will be full of additional significance when we compare his account of another ornament of the southern skies, to be inserted here:—

(ii.) *The Great Cluster* 47 *Toucani*. Gen. Cat. 52. R.A. 0h. 18m. D.S. 72° 52′; immediately *p* the *n* part of the *Nubecula Minor*. This, according to H., is "a most glorious globular cluster—a stupendous object," the last outliers of which extend 2m. 16s. in R.A. from the centre. The stars are nearly equal, 12 to 14 mag.; immensely numerous, and compressed in three distinct stages—being first very gradually, next pretty suddenly, and finally very suddenly very much brighter up to a central blaze, 13·5s. (R.A.) in diam., where they seem to run together; and whose colour is ruddy or orange-yellow (in another observation pale pinkish or rose-colour), contrasting evidently with the white light of the rest—a phenomenon of which he had no doubt. A double star, 11 mag., lies *s p* the centre, probably, as he thought, without any connection with the cluster. The mass is completely insulated; after it has left the field, "the ground of the sky is perfectly black throughout the whole breadth of the sweep." H would have seen here the result of a gradual agglomeration by the power of gravity through the lapse of innumerable ages. Whatever may be the value of the speculation, for which he supposed there was ground in *his* visible heavens in the case of M 4, and another cluster in *Ophiuchus* (H VI. 40), the fact, at any rate, ought not to escape notice. We have to remember that the central blaze is not viewed by us separately, but as projected in perspective among a very considerable proportion of exterior components in front of and behind it, and that its peculiar tint must be consequently lowered by the admixture of white; which would not be the case with a single ruddy star in that position. If the great reflector, which has been so often spoken of as in contemplation for Melbourne, is ever carried into effect, it is to be hoped that it will be provided with one of Browning's most powerful spectroscopes, as the E. of Rosse's telescope has recently been. It is possible that the central colour may not be out of the reach of its analysis; at any rate, very curious results may fairly be expected from its employment in these unexplored regions.

We will now return to our own skies, for a task requiring some little patience at the hands of those not possessed of graduated instruments—the "fishing up" of a most curious planetary nebula, discovered by Struve I., and therefore called—

[45.] Σ 5 N(eb.) Gen. Cat. 4234. R.A. xvih. 39m. D.N. 24° 4′. To find this we must identify two guide-stars, β and ϵ *Herculis*. The former will be recognized by the directions in INT. OBS., ii. 56 (under κ *Herc.*); the latter from those for ζ, in INT. OBS., vi. 117, since ϵ is the next 3 mag. star $f\,\zeta$, a little *s*. About one-third of the distance from β to ϵ, but considerably *s* of the joining line, we must sweep—and in this case, to our annoyance, not with the finder, in which the object would not be distinguished from a small star, but with the telescope itself, and not with a very low power, for the same reason. With $3\frac{7}{10}$ in. I found it better seen with 144 than 80; with $5\frac{1}{4}$ in. it was not quite stellar even with a comet-finding power of 30, though it would have been altogether so with a lesser aperture.

The reason of this disadvantage in smaller instruments is worthy of notice. The apparent telescopic diameter of a star, or its *spurious disc*, is enlarged, from the undulatory nature of light, and the interference occasioned by our insulating a portion of it by the telescope, in proportion to the diminution of the aperture. Old Hevel, who claims to have been the first to notice this, employed his discovery in an amusing way. The fact had been previously remarked that the stars had no visible circular discs in the telescope, but appeared as radiating and sparkling points. Galileo and others had rightly divined the cause—the excessive distance, on which magnifying power would produce no sensible effect; and the sagacious Kepler had gone a step further in observing that the stars appeared smaller in proportion to the excellence of the telescope. But Hevel rejoiced in the discovery that by the application in front of the object-glass of a diaphragm of the size of a large pea! (which, he confesses, destroyed the definition of the moon) he could see them as circular discs of a sensible magnitude, varying according to the brightness of the star; which he says anyone else might do who knew how to use his telescope aright. Little did the worthy Bürgermeister imagine that he was intentionally producing, in 1647, what it is now the object of every observer to get rid of as much as possible. In proportion to his contracted aperture he was increasing the effect of interference, and in doing what he could to make the stars look like planets, was making them look especially unlike themselves. Now this enlarging effect will be more conspicuous on stars than other objects, because of their more vivid light: the luminous border, so to speak, added by interference, being much less intense, as Airy has shown, than the interior of the disc, may be strongly perceptible with the native radiance of the stars, when with reflected lunar or planetary light it impairs definition in a less obvious degree. (And thus by the

way we get the incidental result, that though a reflector when compared with an achromatic of equal light, is, under ordinary circumstances, at some disadvantage, from including in its larger aperture more atmospheric confusion, still, when the air is really steady, its optical definition will surpass that of its rival.) In the case, however, of the nebula from which we have been wandering so far, the effect of larger aperture is twofold in producing a greater contrast, diminishing at once the spurious discs of the stars, and enlarging the real diameter of the nebula, whose fainter edges come into view. The object thus to be at length "swept up" is termed by Sm. a small pale blue planetary nebula, diam. 8″. With my smaller instrument it was exactly like a star out of focus, bearing 300 well; with the larger one it was a bright ball with woolly edges; 65 seemed to show its colour best; with 111 it was encompassed with a glow, not so evident with higher or lower powers. Secchi saw it with 1500 as a sparkling group of stars. Schultz at Upsala, with a 9½ (Paris ?) in. achromatic, has since described it as a very curious object, 9·″6 diam., almost planetary, yet distinctly granulated; it would, he remarked, be an interesting object for Huggins's analysis; and so it has proved. With 8-in. and powers up to 1000, that observer found it had an uniform disc, intensely bright, and decidedly blue, surrounded with a faint nebulous halo; the spectroscope showed three bright lines, with glimpses of a very faint continuous spectrum: as to the greater part, therefore, of its extent, and possibly with slight condensation in some places, this is a ball of incandescent gas, magnitude and distance utterly unknown!

DOUBLE STARS.

Having learned to find the guide-star to M 5, we should examine it in its individual character, as it is really a pretty pair. It will stand in our list as

160. 5 *Serpentis*. 10″·3. 39°·8. 5½, 10½. Pale yellow, light grey.

We will also include, for another reason,

161. *a Serpentis*. 50″. 1°·5. 2½, 15. Pale yellow, fine blue. The attendant, which is called extremely delicate by Sm., forms an excellent test for light, alike from minuteness, distance, and position. With my 9¼ in. speculum it was quite obvious. I do not, however, profess to be able, in general, to detect any colour in these faint points, which were considered by Σ also, if below *his* 9 m. (=9¾ Sm.) to show no certain hue. In achromatics, if near enough to the larger star, they might, perhaps, acquire an adventitious tint from being involved in its outstanding fringe, the freedom from which constitutes one

great advantage of the reflecting telescope. The light of the silvered mirrors is not indeed perfectly white; but it is a curious coincidence that the defect is very similar in quality to that of a well-corrected (*i.e.*, in technical language, *over-corrected*) achromatic, a portion of the blue rays being in either case separated, and so giving a slight complementary orange tint to the remainder. The difference, however, is that in the achromatic they are visible, and with high powers obtrusive, as a luminous fringe; in the silver film they disappear from transmission, so as to leave the image clean.

Occultation.—July 11th. η Libræ, 6 mag., 10h. 15m. to 11h. 25m.

ON THE EGGS OF CORIXA MERCENARIA.

BY DR. T. L. PHIPSON, F.C.S.,

Member of the Chemical Society of Paris, etc.

The eggs of the Mexican insect *Corixa mercenaria* (Say), are interesting, in the first place, because they form an aliment extensively used by man; in the second, inasmuch as they contribute to the oolitic structure of certain fresh water limestones of modern formation. In speaking of this insect production in another place,* I stated with regret that these eggs had not yet been submitted to chemical analysis. When the Mexican traveller, M. Virlet d'Aoust, returned to Paris, he placed in my hands a certain quantity of them, but the greater portion I also distributed among my friends. Recently I have examined, microscopically and chemically, what remained of my specimen, and though the quantity was very small, some unexpected results have been obtained.

For ages the Mexicans have consumed great quantities of these eggs; they find them strewed by millions upon the reeds which grow on the banks of the great fresh-water lakes Texcocco and Chalco. The mode of collecting them is very simple; they are shaken from the reeds into a cloth, and set to dry in the sun, after which they are ground like flour, placed in sacks, and sold to the inhabitants, who make the flour into a kind of cake called *hautlé*. The eggs themselves are spoken of as *Agautle*, and before being ground are used to feed chickens.

It was interesting to ascertain by analysis whether this substance is more or less nutritious than our bread, and, at first sight, it would appear to be infinitely more so.

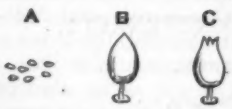
* *The Utilization of Minute Life*, p. 104.

The eggs given to me by M. Virlet were in the state in which they are usually collected. They had been dried in the sun, but not ground, so that their microscopic structure could be examined as well as their chemical composition.

First, with regard to the latter, they have yielded me:—

Water	0·8
Mineral matter	5·0
Organic matter, consisting almost exclusively of Chitine	94·2
	100·0
Nitrogen (per cent.)	6·2

The mineral matter, or ash left after incineration, contains much phosphate of lime, it contains also carbonate of lime, oxide of iron, soda, and silicic acid. The quantity of material in my possession being so small, precluded the possibility of a quantitative analysis of the ash. The organic matter, amounting to 94·2 *per cent.*, consisted almost entirely of Chitine; this curious fact was fully explained when the eggs were submitted to microscopical examination. It was found that the *larvæ* had quitted them. Nothing remained but the rigid envelope of the egg, and its singular little appendix, by which each egg adheres to the surface of the reed. (See Fig.)



A. Natural size.
B. Magnified.
C. The egg after exit of the larva.

Under the microscope, with one quarter inch object-glass, the eggs of the *Corixa* do not differ in appearance from those of a chicken, but underneath the wider extremity of the egg exists a little appendix, in shape like the foot of a wine-glass, which I do not find mentioned in any work on comparative anatomy, and does not seem to have been observed before. The oval portion of the egg appears to be formed of Chitine and mineral matter containing much lime. The little appendix is formed of Chitine alone, and under the microscope appears like ordinary gelatine. The larva leaves the egg by a circular stellated orifice formed at its narrow extremity.

From what precedes, it would appear that the flour formed by grinding these eggs of the *Corixa* must be of a most nutritious nature:—The amount of nitrogen found in the analysis is very large, and agrees nearly with the known composition of Chitine. For it is impossible to admit with M. Fremy that Chitine is a substance analogous to cellulose. In his experiments upon the former, he boiled it with solution of potash, in order, as he stated, to eliminate the albuminous compounds which he supposes associated with it. It is very much more probable that

Chitine is a glucoside $C^{15}H^{13}NO^4$, yielding glucose and lactamide (or some such body) by the action of mineral acids, and boiling with caustic potash decomposes it easily.

But the Editor of this journal has called my attention to the fact, that *Chitinous* substances are known to be very indigestible, so much so, that the chitinous parts of insects are frequently present in the excreta of insectivorous animals; and this would tend to prove that, in spite of the large amount of nitrogen yielded in the analysis, and the fact of the insect flour being baked into cakes, the highly nutritious quality of the latter may be reasonably doubted.

In our climate we have representatives of these Mexican boat-flies in our genus *Notonecta*. Indeed, three species of insects appear to contribute to the formation of the Mexican flour *hautlé*, namely *Corixa mercenaria*, *C. femorata*, and *Notonecta unifasciata*. The first is the most plentiful, the latter is the largest of the three, and resembles our common boat-flies.

This peculiar insect product, which serves as an aliment to a large proportion of the inhabitants of Mexico, was mentioned by the English naturalist, Thomas Gage, in 1625.

M. Virlet has assured himself that the white limestone rock which is forming at the present day in the fresh water lakes Texcocco and Chalco, owes its oolitic structure to the presence of these eggs of the *Corixa* and *Notonecta*. I have observed a very similar structure in the red hematite of Namur (Belgium), and also in a red hematite from Illinois (North America); but the oolitic limestones of the Jura series appear to have a different origin.

ARCHÆOLOGIA.

In the Antonine Itinerary, on the line of road between Calleva (*Silchester*) and Venta Belgarum (*Winchester*), both of them towns of importance, we have a station bearing the name of Vindomis. It was fifteen (Roman) miles from the former place, and twenty-one from the latter. It was evidently a small place, and had left so little trace behind it, that antiquaries were disagreed as to where it stood. Sir Richard Colt Hoare seemed to have given substantial reasons for supposing that the site of Vindomis must be sought at a place called Finkley Farm, close to the old London road, not far from Andover, in Hampshire, and he fixed the exact locality to a spot called Nettle-field, the very name of which would lead us to conclude that it had been ground covering ruins, and therefore out of cultivation, and he had, in fact, obtained from the ground some fragments of Roman pottery. It has proved that Sir Richard Colt Hoare was very nearly correct in his conjecture. On the other side of the road, separated by about two field-lengths from Nettle-field, is a rather boldly-rising elevation, called Tinker's Hill, to which the attention of a gentleman of antiquarian zeal in the neighbourhood, Mr. Charles Lockhart, was attracted by the much more frequent discovery of Roman remains, especially in a field which was named Castle-field, and calling in the assistance of the Rev. E. Kell, F.S.A., they proceeded to excavate. The immediate result was the discovery of a building of considerable dimensions, and of undoubted Roman workmanship. At the last meeting of the Archæological Association, on the evening of June 12, Mr. Kell read a paper giving a detailed account of this discovery. The building, the foundations of which were thus brought to light, consisted of a large room, forming a parallelogram, sixty-six feet six inches in length, and forty-one feet two inches in breadth, lying in a direction not quite east and west, and having in the centre of its eastern end, on the exterior, a much smaller room attached, measuring twenty-two feet two inches in length, by fourteen feet in breadth, which Mr. Kell calls a portico. The large building, which had evidently formed only one apartment, appeared to have had a roof, supported upon two rows of pillars, the bases of which remain, and which were arranged in two rows of seven each, running in a line with the side-walls of the portico. The bases of the columns were four inches long by thirteen inches wide. A large number of the ordinary Roman roofing slates, hexagonal in shape, were found scattered about the building, the nails which held them together remaining in some of them. The floor was simply pitched over with flint stones. There were found distributed on the floor four stones, or rather, as we understand it, large clay tiles, two feet long by sixteen inches broad, artificially laid, which appeared to be intended for places for fires, for their surfaces had been blackened by the burning. There were also found constructions to which Mr. Kell gives the name of furnace, placed in a regular manner at the western end of the room, towards its centre, which Mr. Kell sup-

poses to have been used for culinary purposes, as well as for giving warmth. He describes the most perfect of them as being "a round hole, five feet deep, the sides perpendicular to the bottom." It was thirty-two inches in diameter. "The bottom was paved true all over with stones laid in red clay, the upper side of the stones coloured from the effects of fire." The western portico had had two columns, one on each side, arranged in a manner to leave little doubt that it had been the entrance to the building. No other remains of masonry were found in the vicinity of this building, so that it appears to have stood solitary by itself, close to the Roman road. Within the building, and on the surface of the field outside, were picked up seven or eight fragments of Samian ware, and a considerable quantity of other pottery, the half of a quern, some fragments of glass of several colours, a few objects in metal, of no great interest, and a few Roman coins, the latter chiefly of third brass, and of the later period of the Roman empire in the West.

We feel convinced that Messrs. Lockhart and Kell are correct in identifying the ruins they have discovered on Tinker's Hill with the Vindomis of the Antonine Itinerary, which was no doubt one of the Roman *stations*, or halting-places on the road. On the subject of these *stations*, the reader may be referred to an excellent paper by Mr. C. Roach Smith, in the fourth volume of his valuable *Collectanea Antiqua*, in which he describes one of these establishments, the massive walls of which still remain standing at the village of Thésée, between Tours and Gièvres, in France. They were sufficiently commodious for lodging troops on a march, and for all the purposes of a large posting inn, being furnished with provisions for men and horses, with carriages, and with other necessaries, the allotment and distribution of which were under the inspection of the Government agents, who were controlled by strict legal enactments. This *statio* at Thésée, which is the *Tasciaca* of the Itineraries, is of considerably larger dimensions than that of Vindomis, which we might probably expect, from the difference of these two provinces. The two great cities of Calleva and Venta were only thirty-six Roman miles apart, so that no *statio* of any great magnitude could be wanted on this road between them. In a country like Britain, where the ground has been so highly cultivated, and where the remains of the Roman period have experienced so great destruction, we need not be surprised if no Roman *statio* has been previously discovered, and we are inclined to consider this of Vindomis as the only one of which the remains have yet been traced. The remains discovered by Mr. Roach Smith, at Hartlip, in Kent, and by the late Lord Braybroke, at Ickleton, with which Mr. Kell would compare it—especially the former—were villas, or country mansions, and belonged to an entirely different class. Both Mr. Kell and Mr. Lockhart deserve great commendation for the zeal and judgment to which we owe so interesting a discovery.

Attention has recently been called to the remarkably fine and interesting NORMAN CHURCH at ST. MARGARET'S-AT-CLIFFE, near Dover, and the incumbent, the Rev. E. C. Lucey, is making very meri-

torious efforts for its restoration. It is one of our finest examples of the Norman ecclesiastical architecture of about the middle of the twelfth century. The true character of the church has only been discovered of late years, by the removal of the thick coating of white-wash and other modern applications, which entirely concealed its most beautiful features, and there remains still much work of great interest and beauty which is entirely or nearly concealed from view. Among these hidden or obscured beauties is a very fine early English arch, leading from the nave to the tower, which is at present blocked up with a very ugly white-washed screen and organ loft.

The archæological part of the EXPOSITION UNIVERSELLE, which is at this moment drawing such numerous and distinguished visitors to Paris (in the midst of whom we are at this moment writing), presents some very interesting features. They are chiefly exhibited in that part of the Exhibition which is devoted to the *histoire du travail*, occupying a considerable part of the inner gallery of the building. The interest of this class has been much increased by the care which has been taken to arrange the objects in chronological order. The collection of prehistoric remains of all the countries of western and northern Europe is particularly full and striking, and we can, with great advantage, not only compare the various objects found in this country, but make a separate comparison of those of one country with those of another. The collection of prehistoric remains from Denmark is especially rich. The prehistoric remains found in France by Messrs. Christy and Lartet form a special feature in this part of the Exhibition, and the most interesting case in it is that containing the bones and stones of the "prehistoric period" bearing drawings of animals and other objects, in rude outline, but sometimes very well drawn. This comprehensive examination of them confirms the opinion we have always entertained that these curious monuments are not of the immense antiquity claimed for them. An examination of these numerous cases filled with stone implements will show us to what a great variety of uses stone was applied in rude, and even in comparatively late ages, and also, we can hardly help being convinced that many of these stone implements were made by people who took instruments made of metal as their models. The collection of bronze instruments is richest in those brought from northern Europe. The antiquity of these bronze objects, as well as of the pottery which is ascribed to the prehistoric period, appears to us to be greatly overrated. Much of this early pottery presents a very different character of design and workmanship from that found in our island. We may draw attention, among a crowd of interesting objects, to a bronze helmet and sword belonging to the Museum of Narbonne, which we are more inclined to look upon as belonging to the period of the fall of the Roman empire in the west, than as absolutely prehistoric. There is a good collection of Roman antiquities, among which may be pointed out some examples of tools and implements which are extremely curious. A Roman chariot from Toulouse is also very remarkable, and there is a peculiarly fine collection of large funerary urns, some of a nearly globular

form, and one of a very remarkable character, of Samian ware, apparently of the very late Roman period. The collection of early Frankish and Germanic antiquities is also most interesting, and is well worthy of study—especially some of the Frankish weapons, in iron, such as swords, battle-axes, spear-heads, and bosses of shields. The remains of the Christian Frankish age are also rather numerous, including some fine examples of coffers and reliquaries, and some exceedingly interesting specimens of early enamel. The continuous museum of mediæval art and workmanship in the Exhibition building is very complete, and is arranged with judgment in its different historic periods. Each is rich in its peculiar illuminated manuscripts, in its sculptured ivories, and in an infinite variety of objects, which it would be quite impossible even to enumerate here, and it would be difficult, without much more space at our disposal, to make even a selection. The show of early enamels of Limoges is something wonderful. T. W.

PROGRESS OF INVENTION.

NEW PHOTOGRAPHIC INSTRUMENT.—An ingenious apparatus, termed by the inventor a Photographometer, and intended to record the angular position of objects situated around a given point, has been constructed by M. Chevallier. It is entirely automative, and very simple, so that it may be used by those possessing but little manipulative skill. The record is made by photography, and the camera used, with the exception of certain additions, does not differ much from the ordinary kind. The objective, which is that usually employed by photographers, is mounted vertically on a circular platform capable of rotating, by means of clockwork, in a horizontal plane. The picture is formed, not in a vertical plane, as in ordinary cases, but in a horizontal; and therefore the rays passing in through the objective are deflected 90° by means of a reflecting prism, so as to fall on the sensitive surface, which is collodionized glass, and is placed in such a way that its centre corresponds with the point at which the centre point of the diaphragm would be represented. To prevent a number of confused images, superimposed on each other, being formed during the rotation of the objective, an opaque screen, having a narrow oblong opening, the median line of which passes through the axis of rotation, is placed over the whole of the sensitized surface, and revolves along with the objective. The result of this arrangement is the production on the sensitized plate of images of the different points that lie around the observer; the angles formed by lines joining the centre of the plate, and the different objects being exactly the same as those formed by lines joining the centre of the instrument, and the objects themselves. It is evident that the position of the objects thus accurately obtained may be transferred to paper, etc., in the ordinary way. As different velocities of rotation may be suited to different purposes, three different velocities may be obtained by means of a regulator. And

as it may be wished to mark down only certain points of the panorama, an arrangement is made which secures the attainment of this object. Should it be desired to observe not different points, but successive changes at the same point, the objective and the screen are disconnected, so that only the latter revolves; the successive appearances at the same point are then recorded in succession in a circle round the sensitized plate.

Compound Pipes.—To obviate the dangers which, especially in certain circumstances, have been found to attend the use of leaden pipes, and at the same time to secure the cheapness and other good qualities of lead, a very simple mode of forming pipes, consisting externally of lead, but internally of a thin shell of tin firmly attached to the lead, has been invented. The cylinder of which the pipe is to be formed, by drawing, is externally of lead, but internally of tin, both being firmly united together, and the relative thicknesses of the metals being such, that when the lead is drawn to the proper length, the coating of tin will be of the desired depth. The tin, which very slightly augments the cost of production, will remain entire, however thin the pipe may be, if ordinary care is taken.

Clearing of Ships from Bilge Water or Leakage.—A very simple mode of effecting this is coming into use on the rivers of the Western States of America. It is founded on the principle of Giffard's injectors, and consists in placing in the vessel to be emptied a pipe, in ordinary cases, about two inches in diameter, with one extremity reaching to very nearly the bottom of the hold, and the other projecting through its side a little above the water line. Then inserting the conical extremity of a small pipe leading from the steam boiler, and fitted with a stop-cock, into the end next the bottom of the vessel. If water reaches above the lower end of the larger pipe, turning on steam into the smaller will cause the water to be carried off with great velocity. It is not necessary that the steam boiler should be in the vessel which is to be cleared of water. The steam vessel may be alongside of the barge, etc., which is to be emptied, and the larger pipe may be laid down temporarily, the upper end being merely turned over the side: and steam may be conveyed to the conical nozzle inserted in the lower end of the larger pipe by means of a small flexible pipe leading from the boiler of the steamer.

Economic Production of Oxygen for Industrial Purposes.—Oxygen is now obtained very economically by decomposition of sulphuric acid. This is effected by means of heat, and an apparatus devised for the purpose. The acid is decomposed into oxygen and sulphurous acid, and the latter is removed by liquefaction, effected by pressure. The sulphuric acid employed is not wasted, it is merely the vehicle for obtaining oxygen from the atmosphere, and may therefore be employed over and over again, the sulphurous acid being, after each operation, changed back again into sulphuric acid in the usual way. A kilogramme of sulphuric acid at 60° affords a cubic metre of oxygen.

Modification of the Pneumatic Despatch.—The Pneumatic despatch, as organized at Paris, differs in some points, and advan-

tageously, from that used in this country. The motive power is compressed air, the compression being produced by means of the water supply, which, in Paris, is highly effective, the head of water being very considerable. Water being let into one tank, the air expelled from it by the water is transmitted to an air tank, of which there is one at each extremity of the line. Each of the tanks is of iron plate, and holds about one thousand gallons. The time expended in filling the water tank is about three minutes, and the air thus expelled from it is more than enough to propel the waggon along the entire line, which is about two miles in length. The waggon is of a peculiar form, being a hollow piston about five and a half feet long, closed permanently at one end, and temporarily by a movable lid at the other. Leather washers placed around the closed end, fill up the space between it and the pneumatic tube, which is two and half feet in diameter. The signals between the stations are made by electric bells; the waggon announces its approach by the noise which it makes. When it is to be sent off, it is placed in the mouth of the tube, which is then put in connection with the compressed air, the other extremity being put in connection with the atmosphere, that the air in front of the waggon may have a means of escape. This system is very simple, economic, and effective, but it is applicable only where the head of water is great. In Paris it is very considerable, and a pressure is therefore produced by it which affords a motive power applicable to a great number of useful purposes.

Utilization of the Electric Light.—The brilliant light afforded by electricity naturally suggested, at a very early period, its application to the purposes of illumination. But every project for the purpose was practically impossible, until very great progress had been made in the modes of producing and manipulating that obtained by means of the pile, or the magnet. Galvanic electricity, which in its application preceded that derived from magnetism, appears not unlikely to maintain its ground as a convenient and economic source of light, notwithstanding the numerous and important discoveries that have been made in this department of science. This might fairly be expected: since, at least in those contrivances in which heat and light are the results of the transformation of motion—previously obtained directly from combustion—the effect must be more costly and complicated than when obtained directly from combustion, as is the case with galvanic electricity. The effects produced by the latter is now so economic, and what is still more important, so reliable, that it is being introduced with excellent effect in France, as a means of diffusing to great distances a light so intense, that when it is used, collision at night is impossible. Also, during the intense frosts in January, the skaters in the Bois de Boulogne were enabled, by means of fifteen electric lights, suitably disposed, to enjoy their pastime by night, with at least as much convenience and security as by day. Each of the fifteen lights was produced by the electric current obtained from a Bunsen battery containing forty elements, and placed in a small closed pit, from which the vapours were conveyed away, so as to be the cause of no incon-

venience to those in the vicinity. The carbon points lasted for several hours, affording a light practically uniform; and when they were nearly worn out, a fresh lamp, moving on rails provided for the purpose, was slid into the place of that which was exhausted. In taking its position, it lit of itself: and the displacement of its predecessor caused the worn out points to be extinguished, the change taking place so quietly, and so rapidly, that no interruption of the light was perceptible. A single additional lamp is sufficient to change the fifteen at the proper times, the points being so arranged as to become exhausted in succession.

New Mode of Dissolving Vegetable Fibre.—Various solvents for dissolving vegetable fibre are known; but, besides being most unusually expensive, some of them give rise to explosive compounds. It is found, however, that it is readily dissolved by a strong solution of ammoniated copper. Filtering paper, probably on account of the processes employed in its manufacture, dissolves easily, and without residue, in the cupreous solution. The vegetable fibre is thrown down from the solution thus obtained, as a gelatinous precipitate, by boiling, exposure to the air, or the addition of an acid. The ammoniated sulphate will take up so much of the filtering paper as to form a viscid adhesive mass.

PROCEEDINGS OF LEARNED SOCIETIES.*

ROYAL MICROSCOPICAL SOCIETY.—*June* 12.

Dr. Arthur Farr, F.R.S., V.P.R.M.S., in the Chair.

Dr. Carpenter, F.R.S., gave an interesting account of a binocular microscope by Nachet, which, though less optically perfect than Mr. Wenham's, enabled the cone of rays ordinarily passing to the right eye to be transferred to the left, and the left cone to the right, by pulling out a slide containing the prisms. The effect of this is to convert the instrument into a *pseudoscope*, and to make elevations look like depressions, and *vice versâ*. Dr. Carpenter gave many important illustrations of the principles of stereoscopic vision, and said that to obtain true appearances the angle of aperture of objectives must be moderate in proportion to their focal length. For a half-inch objective he found 40° gave excellent results, and this corresponded very closely with theoretical calculations.

He likewise described a dissecting binocular microscope by Nachet, which he praised highly. The larger instrument had an excellent and very simple mechanical stage—a rotating movement, something like Smith and Beck's "Popular," and other motions made by the hand, and regulated by spring attachments of a glass object-carrier to a glass stage.

Professor Rymer Jones described the wonderful changes that occur in the larvæ of the *Corethra plumicornis*, which he illustrated

* The most important subject that has lately come before the Royal Society will be found in the article on the "Recent Discoveries of Mr. Graham."

by large beautifully-executed diagrams. It appears that the air sacs, which are so conspicuous in this elegant object, suddenly expand, and occasion the development of a complicated trachæal system. The mouth organs and internal structure of this larva were also illustrated in the professor's paper.

Mr. Browning described the spectra obtained by reflected light, from the dichroic fluid, shown at the previous meeting by the Rev. J. B. Reade, and explained that it differed very curiously from that given by transmitted light, part of the yellow being replaced by green.

LITERARY NOTICES.

PHYSICAL GEOGRAPHY, by Professor D. T. ANSTED, M.A., F.R.S., F.R.G.S., F.G.S., Honorary Fellow of King's College, London, and late Fellow of Jesus College, Cambridge. (W. H. Allen and Co.) —We intend to take an early opportunity of noticing this work at greater length, and will now only observe that Professor Ansted has produced an admirable book adapted to the wants of students, whether in colleges or private families. For general reading it is the best work of the kind that we are acquainted with, being written on a comprehensive plan, and in a clear and elegant style. Without any parade of scientific learning, the Professor has brought together in good logical array an immense mass of information, laying his foundation on astronomical considerations of our earth as a planet, and then examining in succession the various causes which have modified its surface, and occasioned the existing distribution of land and water. Atmospheric influences and climate are also well treated, and the work ends with a description of the changes effected by human agency. One great merit of this method of treatment is that the philosophy of the subject is naturally unfolded, and the student is pleasantly and insensibly led from simple elementary facts to those grand generalizations which emphatically constitute science, properly so called.

ARCHIVES OF MEDICINE: a Record of Practical Observations, and Anatomical and Chemical Researches connected with the Investigation and Treatment of Disease. Edited by LIONEL S. BEALE, Vol. IV., No. xvi. (Churchill.)—In addition to notes of cases treated at King's College Hospital, this number contains several important papers. Mr. J. Lockhart Clarke describes a case of paraplegia resulting from a cancerous growth affecting the spinal cord, and Dr. Bateman describes a fatty tumour as big as an egg which grew in the cerebellum of one of his patients. It induced a staggering gait, a jerking spasmodic method of speaking, and partial loss of sight and hearing. Intelligence was unimpaired and memory good. Dr. Morris Tonge describes a case in which fungi were developed in the kidneys; and other papers will well repay professional perusal.

PHOTOGRAPHS OF EMINENT MEDICAL MEN OF ALL COUNTRIES, with brief Analytical Notices of their Works. Edited by W. TINDAL ROBERTSON, M.D., M.R.C.P., Physician to the General Hospital, Not-

tingham, the Photographic Portraits from Life by Ernest Edwards, B.A., Cantab. No. 2, Vol. II. (Churchill).—The present part is devoted to Dr. Carpenter, F.R.S., Mr. N. B. Wood, F.R.S., and Dr. Robert Uvedal West. The portraits are very good, and the letter-press affords a compendious sketch of the biography of their originals. We have no doubt this series will be widely appreciated.

A Handy Book of Meteorology, by Alexander Buchan, M.A., Secretary of the Scottish Meteorological Society. (Blackwood and Sons.)—This is a nicely-arranged and comprehensive treatise, illustrated by woodcuts of apparatus, and five meteorological charts. As the Government have very unwisely suspended the storm-warnings commenced by the late Admiral Fitzroy, we are glad to cite the following sound practical opinion:—"The truth is, no prediction of the weather can be made, at least in the British Islands, for more than three, or perhaps only two days beforehand, and any attempt at longer prediction is illusory. The principles laid down in the chapter on storms show the possibility and mode of making real predictions. Thus, if from telegrams of the weather it appears that barometers are everywhere high over Europe, then no storm need be dreaded for two days at least. That if on the following morning barometers begin to fall in the west of Ireland, and easterly winds blow over Great Britain and Norway, and south-easterly winds over France, it is likely that a storm more or less severe is approaching the British islands. The indications ought now to be closely watched by the telegraph; and if the winds veer towards the south and west, and increase in power, and barometers in Ireland fall rapidly, a great storm is portended, the approach of which should be telegraphed at once to the seaports threatened by it. But if, on the contrary, barometers fall slightly, or cease to fall, and the winds do not increase in strength, the storm has either passed considerably to the north of the British islands, or its approach is delayed, and no immediate warning is necessary."

English Prose Composition: a Practical Manual for the Use of Schools. By James Currie, M.A., Principal of the Church of Scotland Training College, Edinburgh. (Blackwood and Sons.)—The notion of this work is very good, and the execution generally satisfactory, but some of the critical remarks need correction. For example, citing—

> "Then shall love keep the ashes and broken parts
> Of both our broken hearts,"

as a specimen of "forced, unnatural, and obscure expression," is scarcely just. There is not the least obscurity to any one who remembers the practice of collecting in memorial urns ashes and osseous fragments from the funeral pyre. The objection to the figure is the confusion of thought involved in the "broken parts" and "broken hearts," the one somewhat clumsily referring to the incidents of cremation, and the other to a purely figurative "breaking." The broad, unqualified statement, that "mixed figures should be avoided, as detracting both from clearness and beauty," is not justifiable, as some fine passages from great authors could be

cited, in which mixed figures have been advantageously employed. In Ben Jonson's famous poem beginning "Truth is the trial of itself," we have the following verse:—

> "It is the warrant of the word
> That yields a scent so sweet,
> As gives to faith its power to tread
> All falsehood under feet."

Here the figures are ably and elegantly mixed. The real objection to what Mr. Currie calls "mixture" is, the juxtaposition of figures that will not *mix*, by reason of their incongruity, as in the instance he gives—"There is not a single *view* of human nature which is not sufficient to *extinguish* the *seeds* of pride"—a sentence which looks like a bit of a leader from the *Telegraph*. On the whole, we like the book, though we should object to making "paraphrasing," a prominent part in any system of teaching. If good authors are selected for this process, the pupil is simply taught to say a good thing in a worse manner than it has been said before.

First Steps in Geography; Geography of the British Empire. Both by the Rev. Alexander Mackay, LL.D., F.R.G.S., author of "A Manual of Modern Geography," etc. (Blackwood.)—We do not believe in threepenny and fourpenny geographies—not that we have any objection to articles of low price, if it is possible to make them good for the money; but "First Steps in Geography" in fifty-six very small pages must necessarily be very dry and very incomplete. The simpler elements of physical geography should be taught first, and political geography at a later period, if the pupils are to be interested in the study, and to gain ideas instead of mere words. At the second page of "First Steps" we find a wrong step taken, and a false idea given. The writer says, speaking of the oceans, "They are not *entirely* separated from each other, like the continents"—thus giving an erroneous notion of the continents of which Europe, Asia, and Africa are three portions of one great continent, and not as distinct as the passage cited would convey.

NOTES AND MEMORANDA.

Bromide of Potassium in Epilepsy.—M. Namias states in *Comptes Rendus* that bromide of potassium, beginning with one gramme taken during the day in three doses, and increasing it to several grammes in twenty-four hours, diminishes the violence and the number of epileptic attacks.

Weakness of Wheat Stems.—M. Velter examines, in *Comptes Rendus*, the cause of that weakness of wheat stems which allows the plant to be laid by wind and rain. He remarks that M. Pierre had shown that laid wheat often contained more silica than that which remained standing, and his own experiments led him to consider a manure of silicate of potash mischievous. He says that wheat becomes laid not for want of silica, but because the ligneous matter of the straw is not well developed. He also states that a microscopic examination shows the deposit of silica to be discontinuous, and not to form a compact framework.

Ophthalmic use of Sulphate of Soda.—M. D. de Lucca states (*Comptes Rendus*) that the powder of crystallized sulphate of soda dropped in small quantities on the cornea, and allowed to dissolve in the fluids of that organ will, in the course of time remove opaque spots.

THE CRATER LINNÉ.—M. Chacornac sees divergent rays like the glory of a saint round this object. P. Secchi writes to the French Academy that Professor Respighi and his assistant, P. Ferrari, of the Capitoline Observatory, Rome, find that with a power of 500, which diminishes irradiation, a funnel-shaped cavity can still be discerned, so that the lower cavity has not disappeared, although the crater is very flat. This appears to correspond with the statement of the Astronomer Royal in his recent report to the Board of Visitors, "that drawings of the spot Linneus on the moon leave no doubt that it is still a very shallow cup."

THE OPALS OF CALIFORNIA.—It is stated in *Cosmos* that the Californian opals are found in ancient decomposed lavas, and that the matrix of the gem is saturated with water, and the opals themselves soft enough to break between the fingers when first dug. Exposure to the sun for several days hardens them and brings out their lustre. The best are enveloped in a ferruginous crust, while those which are white and of feeble colour are without this covering.

OBSERVATIONS ON CHLOROPHYLL.—M. Marc Micheli has a paper on this subject in the *Archives des Sciences*, and he thus sums up his conclusions: 1. There is not sufficient proof to admit Frémy's hypothesis, that chlorophyll is decomposable into phyllocyanine and phylloxanthine. 2. Chlorophyll appears to be formed of a yellow substance, which transforms itself into a green one in a manner which is unknown. 3. All acids destroy the colour of chlorophyll, and turn it yellow. 4. Two of them, SO_3 and HCl, possess the property of changing this yellow into blue or green, according to which is employed, and baryta acts in an analogous manner. 5. Light does not discolour the green and blue obtained by SO_3 or HCl; it is not therefore the same colour which is found in chlorophyll. 6. Many leaves become transparent in full sunshine, an effect which seems to arise from the contraction of the chlorophyll granules.

EHRENBERG ON THE HYALONEMA.—The *Annals Nat. Hist.* contains a translation of a paper by Professor Ehrenberg, on the *Hyalonema Lusitanicum*, discovered by Professor Borboza da Bocage. His conclusions are that the Hyalonema is not a polyp, but a sponge. He considers, which can scarcely be justified by facts, that the essential character of sponges coincide with that of vegetable bodies, and he imagines the "supposed normally protruding tufts of Hyalonema, when they occur on true sponge structures, to be mutilations by the loss of the apices of those sponges, like the dead points of horny corals, just as the deciduous trees in the north, or on elevations, often bear antler-like dead summits, while the trunk is still well furnished with foliage."

THE MOTOR CLOCK OF THE GREENWICH OBSERVATORY.—The following passages occur in the report to the visitors: "this clock is compared and verified by an easy practical process. It maintains various clocks in sympathy with itself, it regulates clocks in London, sends signals through Britain, drops the Deal time-ball, fires guns at Newcastle and Shields (I think also at Sunderland), and puts communications in such a state that we can receive automatic reports from the signal-places as we may desire. I may, however, specially mention that daily signals are now sent to some places in Ireland; and that, during the expedition of the Great Eastern for laying down the Atlantic cable, time signals were sent on board twice a day, to enable her constantly to determine her longitude."

THE HOUSES OF PARLIAMENT CLOCK.—The Astronomer Royal reports that on 38 per cent. of the days of observation, the clock's error was below 1^s; on 38 per cent. of days of observation, between 1^s and 2^s; on 21 per cent., between 2^s and 3^s; on 2 per cent., between 3^s and 4^s; on 1 per cent., between 4^s and 5^s.

ARTIFICIAL RESPIRATION AND STRYCHNINE.—M. J. Rosenthal states, in *Comptes Rendus*, that by exciting artificial respiration, and maintaining it for three or four hours, it is possible to save the life of an animal to which a poisonous dose of strychnine has been administered.

INDEX.

Absorption of gases by colloid septa, 452.
Absorption of heated air, 458.
Action of trees on rainfall, 400.
Acoustic figures, 79.
Ægilops ovata, 264.
Ægilops triticoides, 263.
Aerial navigation, 400.
Aeronautical Society, 374.
Agautle, Mexican eggs, 467.
Air changed in composition, 454.
"Alice," Mrs. Cameron's photographs, 31
Alkalis, colours affected by, 409.
Alloys used in ancient jewelry, 5.
Alternation and periodicity, law of, 19.
Anatina, 18.
Anatomy of the woodpecker, 321.
Ancient conduits, 257.
Ancient jewelry, 1.
Ancient lighthouses, 325.
Ancient men in Wirtemberg, 450.
Ancient personal ornaments, 394.
Ancient supply of water to towns, 257.
Andromeda nebulæ, 386.
Angle measurer, 79.
Anglo-Saxon cemetery, Woodstone, 223.
Anemometer, self-recording, 320.
Animal magnetism and magnetic lucid somnambulism, 78.
Annulus pronubus, 403.
Annual report of the board of regents of the Smithsonian Institution, 232.
Anomalies in the vegetable kingdom, 446. [334.
Antarctic temperate zone low barometer,
Anthracite coal-field, 35.
Anthercea Pernyi, 242.
Antiquities of the Cheshire coast, 307.
Antiquities of the Duc de Blacas, 401.
Ant lion, 112.
Ants, white, 112.
Apparatus for condensing light, 396.
Apparatus for sun-viewing, 432.
Application of air charged with combustible vapours, 314.
Applicability of the electric light to lighthouses, 325.
Aqua claudia, 260.
Aqua marcia, 261.
Aqueducts, 258.
Archæologia, 74, 152, 223, 307, 393, 470.
Archæology.—Ancient jewelry, 1; relics at Thebes, 2; Assyrian relic, 3; relics of Queen Aah-hept, 3; Treveneage cave, 74; sculpture rocks, 75; bone-caves, 76; Roman town, 77; Mayer Museum, 152; Treveneage cave, 153; St. Hilary's church, 154; Roman building, 154; reliquary, 155; products of sea-shore of Cheshire, 155; Anglo-Saxon cemeteries, 223; Treveneage cave, 223; spindle-whorl, 223; Roman villa, 224; coins, 225; forged flint implements, 225; Roman remains at Cirencester, 226; forged antiquities, 307; antiquities in Cheshire, 307; statue to Joseph Mayer, 308; Roman sepulchral remains, 308; Roman Uriconium, 309; Roman leaden coffins, 310; prehistoric art, 320; tumuli of Yorkshire Wolds, 393; Celtic foundry of the bronze age, 394; excavations at Wroxeter, 395; ancient men of Wirtemberg, 450; Vindomis, 470; Norman church at St. Margaret's Cliff, 471; archæological part of Paris exhibition, 472.
Archæological part of Exposition Universelle, 472.
Archæological products of the sea-shore of Cheshire, 155.
Architecture, progress of, 418.
Archives of medicine, 477.
Aristillus and Autolycus (lunar), 195.
Aristoteles, 282.
Arithmetic, modern, 233. [397.
Armour-plates protected from corrosion,
Artificial respiration and strychnine, 480.
Artistic decoration of wall surface made permanent, 409.
Aspergillum vaginiferum, 18.
Assyrian jewelry. 1.
Astronomy, descriptive, 231.
Astronomy.—Light spots in lunar night, 51; phosphorescent spots on the moon, 51; Mare Imbrium, 51; Schröter investigations, Manilius, 52; Menelaus, 52; Proclus, 53; crater Linné, 58; occultations, 60; guaging the light spots on the moon, and checking additions, 79; Rutherford's celestial photography, 79; simultaneous concealment of Jupiter's satellites, 79; planet Mars, 80; Schröter's meteors, 144; telescope meteors, 145; lunar Cassini, 147; crimson star, 149; occultation, 151; researches on solar physics, 158; Tempel's comet and shooting stars, 159; Fayé on the sun's rotation, 159;

Wray's object glasses, 160; lunar delineation, 195; lunar Aristillus and Autolycus, 195; occultations, 205; Biela's comet, 208; fresh notes on crater Linné and supposed lunar eruptions, 215; Mare Serenitatis, 217; products of volcanic action, 218; mud volcano in moon, 221; Secchi on Linné, 222; descriptive astronomy, 231; shadow during solar eclipse, 237; photographing the moon, 239; solar eclipse, March 6, 240; lunar perspective, 267; Rhæticus, true form, 267; lunar crater, Plato, 273; red star, 275; double stars, 277; nebulæ, 277; gaseous nebulæ in Hydra, 278; great spiral nebula, 280; Linné, 282; Aristoteles, 282; occultations, 283; Handbook of Astronomy, 317; Huggins on the spectrum of Mars, 319; Browning's sun-screen, 319; November meteors, 320; lunar Apennines, 379; Hadley, 382; Aratus, 382; Huygens, 383; clusters and nebulæ, 384; Canes Venatici, 384; nebula of Andromeda, 386; occultation, 387; moon colours, 388; Linné, 388; homochromoscope, 389; probable connection of shooting stars with comets, 390; Biela's comet, 391; sun viewing and drawing, 429; "willow-leaf" and "rice-grain," 430; darkened shutter for viewing the sun by projection on a screen, 432; measuring spots on the sun, 434; solar diameter, 437: Huygenian lenses, 438; life-history of a group of sun-spots, 441; crystallization, 445; clusters and nebulæ, 459; great cluster Libra, 459; Serpens, 460; ω Centauri, 461; colour of stellar clusters, 463; Toucani, 464; double stars, 466; occultations, 467; crater Linné, 480.

Atmospheric phenomenon, 335.

Auriculida, 24.

Autolycus and Aristillus (lunar), 195.

Bain's kloof, 252.

Bala beds, 352.

Baltimore oriole's nest, 419.

Barker's mill, 427.

Barlow lens, 179.

Barometer of Antarctic temperate zone, 334.

Barometric pressure increase, 335.

Barrande on the graptolites, 366.

Barrels, new mode of constructing, 226.

Baryta-water for wall-painting, 412.

Bichloride of platinum, 181.

Biela's comet, 208, 391.

Blacas, collection of antiquities, 401.

Binocular microscope, 476.

Bird's eggs and their products, 160.

Birds of Europe—Gould's, 322.

Bird's-nests, philosophy of, 413.

Birds of Norfolk, 235.

Bivalve mollusca, 163.

Boiling water in rotation, 160.

Bombyx Cynthia, 241.

Bone-caves of Craven, 76.

Bones and reindeer horn found at Wirtemberg, 450.

Borax used by jewellers, 5.

Botanical origin of wheat, 262.

Botany—Fossil forest of Atanakerdluk, 61; fossil flora, 61; four species of oaks, 61; mangrove and its allies, 65; rhizophora, 65; roots of mangroves, 66; banyan fig-tree, 67; red mangrove, 67; cerriops, 68; kandelia, 68; brugueira, 68; Garden Oracle and Floricultural Year-book, 77; vegetable sheep of New Zealand, 128; compositæ, 128; Tasmanian dogwood, 128; common aster, 128; musk wood, 128; raoulia, 128; haastia pulvinaris, 129; gnaphalium, 129; helichrysum, 129; raoulia Australis, 129; raoulia tenuicaulis, 130; raoulia haastii, 130; raoulia Munroi, 130; raoulia subulata, 130; raoulia eximia, 130; raoulia Hectori, 131; raoulia glabra, 131; raoulia subsericea, 131; raoulia grandiflora, 131; raoulia mammillaris, 132; raoulia bryoides, 132; leaves and flowers of vegetable sheep, 133; oaks of China, 242; trees of the Paarl, 247; vineyards of the Paarl, 247; flowers of the Paarl, 247; Cape Colony flowers and trees, 247; sugar bush, (protea nana?), 249; wild sacha, 249; grey lichens, 250; waggon-boom, 251; silver-trees, 251; oaks at Bain's Kloof, 252; prionium palmita, 252; Cape bulbs, 253; African tulip, 253; ixias and gladiolas, 253; trumpet lily, 253; blood-flowers, 256; Watsonia angusta, 256; tonka bean, 256; aponogeton distachyon, 256; wild olive, 256; botanical origin of wheat, 262; triticum vulgare, 263; ægilops ovata, 263; ægilops triticoides, 263; potatoes, 266; vegetable monstrosities, 446; poppy, curious anomaly, 447; fern variations, 447; gourds, 447; pumpkins, 448; Datura tatula, 448; weakness of wheat stems, 479.

Brachiopoda, 26.

British fossil oxen, 238.

British woodpeckers, 321.

Bromide of potassium in epilepsy, 479.

Bronze dagger, ancient, 393.
Bronze object, ancient, 472.
Bronze implements found in France, 394.
Browning's sun-screen, 319.
Browning's telescopes, 176.
Brugueira, 68.
Buckie, 163.
Bulbocerus, 112.
Bulmius, 24.
Burning the dead, 309.
Butterflies, mimetic, 399.

Cab of Delacroix, 151.
Caged woodpecker, 323.
Calamary, 28.
Calderon's Home after Victory, 363.
Cameo of the Emperor Augustus in the Blacas Collection, 401.
Cameo, finest known, 406.
Cameo of the monks of St. Alban's, 405.
Candles, Ancient Roman, 355.
Canes Venatici, 384.
Canon Greenwell's researches, 393.
Cape Colony, an eight days' ramble, 246.
Caprimulgidæ nests, 416.
Caradoc beds, 352.
Carter's sheep, 364.
Cassella's embossing self-recording anemometer, 320.
Cassini, lunar, 147.
Caterpillars' eyes, 80.
Cave Treveneage, the, 74.
Celtic foundry of the Bronze age, 394.
Cell formations, experiments on, 244,
Cemeteries at Wroxeter, 309.
Centauri cluster, 461.
Centre of gravity, 346.
Ceriops (mangrove), 68.
Cerithium telescopium, 171.
Chasing in ancient jewelry, 6.
Chemical aids to art, 180, 409.
Chemistry.—Formation of crystals, 63; galvanic battery, 63; photography under water, 64; petroleum lamps, 64; petroleum in Italy, 80; molecular force in liquids, 80; galvanic battery, 156; electrical machine, 156; Plateau's liquid, 160; boiling water in rotation, 160; chemical aids to art, 180; platinum, 180; chemical test or re-agent, 180; bichloride of platinum, 181; platinizing process, 182; osteoplastic, 184; oxide of zinc, 185; oxyhydrogen lime light, 226; preservative coatings for metals, 227; new process for obtaining oxygen of chlorine, 229; heliochromy, 229; production of iron and copper ore, 230; action of quinine on the nerves, 240; new source of the tanning principle, 310; peculiar application of electricity, 311; application of sulphuret of carbon to the preparation of perfumes, 312; application of air charged with composite vapours, 314; new application of photography, 314; reinforcement of photographic negatives, 314; estimation of silex of wheat, 315; sensitive litmus paper, 315; new apparatus for condensing light, 396; economic mode of reducing light, 397; protection of armour plates from corrosion, 397; occlusion of hydrogen by meteoric iron, 397; stability of gun cotton, 399; chemical aids to art, 409; size used in distemper and fresco painting, 409; stereochromy, 409; lime or baryta water, 410; silicious bloom, 410; copal process, 412; Graham's researches into the diffusion of gases, 452; absorption and dialytic separation of gases by colloid septa, 452; occlusion of gases, 452; Torricellian vacuum, 453; Sprengel's mercurial exhauster, 453; penetration of India-rubber by gases, 454; passage of gases through platinum, 455; occlusion of carbonic acid gas, 458; economic production of oxygen for industrial purposes, 474; utilization of electric light, 475; chlorophyll, 480.
Cholera and diarrhœa, 157.
Chlorine or oxygen, new process for obtaining, 229.
Christy's *Reliquiæ Aquitanicæ*, shells figured in, 167.
Cicindelas, Indian insects, 112.
Circulation of air, 340.
Civil law, 101.
Chlorophyll, notes on, 480.
Clavagella, 18.
Clearing of ships from bilge water or leakage, 474.
Climacograptus, 370.
Climate of Great Britain, 113.
Clock of Houses of Parliament, 480.
Clodograpsus, 369.
Cluster, Centauri, 461.
Clusters and nebulæ, 384.
Clusters and nebulæ, southern, 459.
Cluster in Libra, 459.
Cluster, Toucani, 464.
Coal-fields of United States, 34.
Cockles, 163.
Cocoons, 243.
Coinage of Great Britain, 10.
Coleoptera, Indian insects, 111.
Cole's marine painting, 364.
Colossus of Rhodes, 325.
Colours for fresco painting, 409.

Colour of lunar seas, 388.
Comet, Biela's, 208, 391.
Comets connected with shooting stars, 390.
Comet and shooting stars, 159.
Compositæ, 128.
Compound pipes, 474.
Condensing light apparatus, 396.
Conditions of illumination as to vertical angle and lateral direction, 198.
Conduits, ancient, 257.
Configuration of land and water upon the northern and southern hemispheres, 338.
Conglomerate, base of coal-fields, 37.
Conglomerate deposit, 187.
Conic section, easy introduction, 233.
Conon crater, 381.
Conspiracy, laws against, 106.
Copal process, 412.
Cope's "Jessica and Shylock," 361.
Copper, economic mode of reducing, 397.
Corethra plumicornis, larvæ, 476.
Corixa mercenaria, eggs, 467.
Corrosion, protection of armour plates from, 397.
Court of the Star Chamber, 99.
Cowry, 20.
Crank bird, 324.
Crater Linné, 58, 215, 222, 388, 480.
Crimson star, 149.
Craven bone caves, 76.
Criminal court, 102.
Crow's nests, 416.
Crystals, formation of, 63.
Crystallization and subsidence, 445.
Curative properties of ancient gems, 405.
Cures produced by a vibrating string, 228.
Cuttle fish, 164.
Cymbra olla, 19.
Cypræa, 20.
Cypræa turdus, 19.
Cylinder seal-ring, 6.
Cyrtograpsus, 369.

Dactyliotheca of Mithridates, 404.
Daguerreotype process of producing black, 230.
Damascening, 183.
Danish prehistoric remains, 472.
Datura tatula, 448.
Decoloration of feathers, 172.
Delineation, lunar, 195.
Dendrograptus, 370.
Depicting solar phenomena by projecting sun's image on a screen, 429.
Descriptive astronomy, 231.
Development of graptolites, 290.
Devitrification of glass, 319.
Dew, an essay on, 78.
Dialytic separation of colloid septa, 452.
Diarrhœa and cholera, 157.
Dichograpsus, 369.
Dichroic liquid, 399.
Dicranograptus, 371.
Didymograpsus, 367.
Diffusion of gases, 452.
Dioptric light, expense of, 332.
Diplograpsus, 366.
Disappearance of Biela's comet, 214.
Discina, 26.
Discovery of Biela's comet, 208.
Dissecting binocular microscope, 476.
Dissolving vegetable fibre, 476.
Distemper and fresco painting, 409.
Diurnal temperature, 122.
Diverging rays, 138.
Domestic architecture of human race, 414.
Donax anatinus, 18.
Double graptolite, 287.
Double stars, 277, 466.
Downy woodpecker, 324.
Drawing and sun viewing, 429.
Dredging, 19.
Drummond light, 396.
Duck and geese shooting in Cape Colony, 254.
Dungeness Lighthouse, 329.

Eagles of Cape Colony, 251.
Earrings, ancient, 2.
Earring from Babylon, 7.
Ear-shells, 235.
Economic fuze for mining and other purposes, 156.
Economic mode of reducing copper, 397.
Economic production of oxygen for industrial purposes, 475.
Economic use of shells and their inhabitants, 161.
Effects of difference of climate on frescoes, 409.
Efflorescence on fresco paintings, 410.
Eggs of Corixa mercenaria, 467.
Ehrenberg on the hyalonema, 480.
Eight days ramble in Cape Colony, 246.
Elder brethren of Trinity House, 332.
Electric energy, 320.
Electric lamps, 330.
Electric light, 327.
Electric light applicable to lighthouses, 325.
Electric light utilized, 475.
Electricity, peculiar application of, 311.
Electricity, students text-book of, 234.
Electric telegraph, 317.
Electric thermometer, self-registering, 228.
Electric machine, 156.
Elements, the, 78.
Emission of light, 139.
Enamelled ornaments, 184.
English law, 97.

English prose composition, 478.
Engraved gems, 403.
Engraving on steel, 396.
Entomology.—Eyes of caterpillars, 80; Indian insects, 110; flying bugs, 111; coleoptera, 111; cicindelæ, 112; bulboceros, 112; hemiptera, 112; reduvius, 112; orthoptera, 112; neuropterous, 112; ant lion, 112; black ant, 112; termites, 112; mimetic butterflies, 399; corixa mercenaria, 467.
Eozoon, new specimens, 398.
Epilepsy, bromide of potassium, 479.
Eratosthenes crater, 370.
Eruption lunar, 216.
Eulima, 19.
Excavations at Wroxeter, 395.
Expansive effects due to liberation of heat as vapour is condensed, 341.
Exposition Universelle, Archæological part, 472.
Expulsive effects due to vapour raised from southern oceans, 341.
External ornamentation of shells, 18.
Evaporation of water, 342.
Eyes of caterpillars, 80.

Fatio on feathers, their decoloration, 172.
Fauna and flora found at Wirtemberg, 451.
Fayé on the sun's rotation, 159.
Feathers, Fatio on, 172.
Feathering oars, 422.
Felspathic ashes, 352.
Fern monstrosities, 447.
Filagree, origin of, 6.
First annual report of the Aeronautical Society, 374.
Fish, rumination in, 190.
Fixing fresco paintings, 410.
Floating shells, 27.
Flowers of South Africa, 253.
Flying bugs, 111.
Flying machines, 374.
Food of heron, 79.
Forged antiquities, 307.
Forest frequenters, 321.
Forged flint implements, 225.
Form, growth, and construction of shells, 18.
Form of graptolite, 289.
Formation of crystals, 63.
Fossils, 350.
Fossil flora of Greenland, 61.
Fossils in Shropshire, 189.
Fossil ivory, 72.
Fossils obtained from laurentian rocks, 398.
Fossil oxen, 238.
French lighthouse engineers, 330.
Fresco painting, 409.
Fresh notes on the crater Linné, and supposed lunar eruptions, 215.
Fresh-water valved vaginicola, 205.
Friction of celestial bodies and ether, 80.
Frith's "King Charles Second's last Sunday," 360.
Fuze for mining, 156.

Galvanic battery, new, 156.
Galvanic battery, simple forms of, 63.
Garden snail, 19.
Gastrochœna, 18.
Gaseous nebula in hydra, 278.
Gases, occulsion of, 452.
Gasteropod, 26.
Gauging the light of spots on the moon, and checking additions, 79.
Geese and duck shooting in Cape Colony, 254.
Geological Society, 159, 238, 398.
Geology—Coal mines of the United States, 34; bituminous coal, 35; anthracite coal-field, 35; Schuylkill district, 36; Swatara, 36; conglomerate, 37; limestones, 37; silurian, 37; Devonian formations, 37; Susquehannah district, 38; Geological Society, 159; telerpeton elginense, 159; mineral wealth of Shropshire, 185; geology of Shropshire, 186; laurentian rocks, 186; sandstone strata, 186; fossils, 187; conglomerate, 187; Stiperstone range, 188; quartzose, 188; Llandeilo formation, 189; volcanic and plutonic rocks, 220; igneous rocks, 220; fossil crustacea, 233; Geology and Genesis, 233; geology for general readers, 235; Geological Society, 238; fossil oxen, 238; silurian life, 240; Stiperstone range, 348; Llandeilo rocks, 348; lower silurian rocks, 348; geological phenomena, 349; lingula flags, 350; felspathic aglomerates, 350; ogygia buchii, 351; organic remains, 351; shale and grit, 352; Caradoc and Bala beds, 352; lead ingot, 354; Geological Society, new specimens eozoon, 398; fossils obtained from laurentian rocks of Canada, 398; opals of California, 480.
Geology for general readers, 235.
Geology of Shropshire, 186.
Gibbus lyonetti, 20.
Gilding porcelain, 312.
Glass rope hyalonema, 81.
Glazing of porcelain, 396.
Globular cluster ω Centauri, 461.
Gnaphalium, 129.
Golden-winged woodpecker, 325.
Gold plate and inlaying, 8.
Goodall's "Rachel," 364.
Gould's "Birds of Europe," 322.

Gourd monstrosities, 448.
Graham's recent discoveries, 452.
Graptolites, their structure and systematic position, 283, 365.
Graptolitus scalaris, 284.
Grates of coals to warn mariner, 326.
Great black woodpecker, 325.
Great cluster in Libra, 459.
Great cluster Toucani, 464.
Great globular cluster ω Centauri, 461.
Great spiral nebula, 280.
Great spotted woodpecker, 322.
Greek coins found at Gurnard Bay, 154.
Greenwich observatory motor clock, 480.
Green Woodpecker, 322.
Gregarinæ in chignons, 239.
Gregariniferous parasites, 239.
Gulls' feathers, 173.
Gun cotton stability, 399.

HABITS of green woodpecker, 322.
Hairy woodpecker, 325.
Haliotis, 163.
Handbook of astronomy, 317.
Handbook of meteorology, 478.
Hart's "Barbarossa submitting to the Pope," 362.
Heat, irregularities of, 125.
Heron, food of, 79.
Highland lass reading, 363.
Helicidæ, 20.
Heliochromy on paper, 229.
Heliophotography, 431.
Helix aspersa, garden snail, 19.
Herculis juvenis engraved on a sapphire, 401.
Hermit crabs, 24.
Hero's engine, 427.
Home after victory, 363.
Homo-chromoscope, 389.
Hookscapes, 362.
Houses of Parliament clock, 480.
House visitants, Indian insects, 110.
Huggins on the spectrum of Mars, 319.
Humidity of English climate, 121.
Huygenian lenses, 438.
Huygens, lunar, 383.
Hyalonema, Ehrenberg on, 480.
Hyalonema, glass rope, 81.
Hyalonema, polyps of, 239.
Hydrogen, penetration of, 456.
Hydrozoa, 373.

ICELAND, north-west peninsula, 319.
Igneous rocks, 220.
Implements of ancient jewellers, 8.
Importance of lighthouses, 325.
Indian insects, house visitants, 110.
Ingot of lead from Linley, 354.
Inlaid stones, 8.
Inlaid silver, 183.
Insects, Indian, 110.
Insects in Mexico, 467.
Instinct and reason, 413.
Intaglios in the Blacas collection, 407.
Iron produced from copper ore, 230.
Isochimenal, 117.
Isotherm of London, 116.
Isotheral of London, 118.
Ivory, fossil, 72.

JAPANESE inventions, 83.
Japanese specimens of glass rope, 85.
Jewel of Polycrates, 402.
Jewelry, ancient, 1.
Julius Cæsar engraved on a jacynth, 407.
Jupiter's satellites, simultaneous concealment of, 79.

KANDELIA, mangrove, 68.
Kingfisher's feathers, 236.
Kingfisher's nests, 416.
King's Council, 96.
Kites, flight of, 377.

LAKE Vogelsolei, 253.
Lamellicorn beetles, 112.
Lamps for lighthouses, 326.
Lamps, new, 399.
Lamp shells, 25.
Larks nests, 416.
Larvæ of Corethia plumicornis, 476.
Law of alternation and periodicity, 19.
Law of libel, 105.
Leaves and flowers of the vegetable sheep, 133.
Lenses for lighthouses, 326.
Lesser spotted woodpecker, 324.
Libration in latitude and longitude, general results of, 271.
Libra, great cluster in, 459.
Life history of a group of solar spots, 441.
Life-sized heads by Mrs. Cameron, 32.
Lighthouses using electric light, 325.
Light: its influence, 318.
Light spots in the lunar night—the crater Linné, occultations, 51.
Lingula, 26.
Lingula flags, 349.
Linnæan spelling, 365.
Linné, 281.
Linné crater, 58, 215, 480.
Linné, Schmidt on, 152.
Literary notices, 77, 157, 231, 317, 477.
Litorina litorea, 164.
Living mollusk, 24.
Llandeilo rocks, 348.
Llandovery, 353.
Low barometer due to absolute difference of level, 347.
Low barometer of the Antartic temperate zone, 334.

Lower silurian rocks, 348.
Lunar Aristillus and Autolycus, 195.
Lunar Apennines, clusters and nebulæ, occultation, 379.
Lunar Cassini, 147.
Lunar crater Linné, 388.
Lunar crater Plato, 273.
Lunar delineation—the lunar Aristillus and Autolycus, 195.
Lunar eruptions, 215.
Lunar perspective, 267.
Lunar shadows, 380.
Lutraria, 18.

MACLISE's Othello and Desdemona, 359.
Magilus, 19.
Mahometan intaglios, 408.
Malay houses, 414.
Mammoth in Bay of Tas, 240.
Mammoth and its epoch, 70.
Mammoth skeletons, 72.
Mangrove and its allies, 65.
Manilius, 52.
Mare Imbrium, 51, 380.
Marine engine, 424.
Mars, 80.
Maury's theory, 340.
Mayer Museum, 152.
Mayer statue, 308.
Measuring minute portions of time by sonorous vibrations, 311.
Measuring spots on the sun, 436.
Mediæval collections of gems, 405.
Menelaus, 52.
Meteoric iron, 397.
Meteorological observations at Kew Observatory, 44, 294.
Meteorology, 334.
Meteorology, handbook, 478.
Meteors, November, 320.
Meteors, Schröter's, 144.
Meteor showers, 392.
Method of measuring sun spots, 435.
Mexican boat flies, 469.
Mexican insects, 467.
Microscopes, 316.
MICROSCOPY. — Royal Microscopical Society, 239, 399; white cloud illumination for low powers, soirée of Microscopical Society, 316; Dichroiscope, 316; travelling microscope, 316; pocket microscopes, 316; Royal Microscopical Society, 399; camphine lamps, 399; binocular microscopes, 476.
Middle spotted woodpecker, 325.
Midas ring, 403.
Millais's "Jephthah," 363.
Mimetic butterflies, 399.
Mints, ancient, 10.
Mint pyx assay, 12.
Mithridates's museum of rings, 404.
Modifications of the pneumatic despatch, 474.
Molecular force in liquids, 80.
Mollusca, 18, 161.
Molluscs applied in commerce, arts, and manufacture, 166.
Money-cowry, 168.
Monograph of British fossil crustacea, 233.
Monoprion group, 366.
Monstrosities, vegetable, 446.
Moon colours, 388.
Mosses found in Wirtemberg, 450.
Mother Carey's chickens, 362.
Motor clock of Greenwich Observatory, 480.
Mould for casting rings, 3.
Mr. Graham's recent discoveries: the absorption and dialytic separation of gases by colloid septa—the occlusion of gases, 452.
Mrs. Cameron's photographs, 30.
Mud-huts of the Egyptians, 414.
Murex adustus, 20.
Murex tenuispina, 20.
Mud volcano in the moon, 221.
Muricidæ, 19, 24.
Muscular action of a fish's stomach, 190.
Museum of mediæval art at the exhibition, 473.
Museum of rings, 404.
Mussels, 162.
Mussulman antiquities, 408.
Mya, 25.
Myra, 18.
Myrmecoleon (ant lion), 112.
Mytilus edulis, 162.

NATIVE houses of America, 414.
NATURAL HISTORY, including ZOOLOGY.—Form, growth, and construction of shells, 18; siphons, 18; tellina solidula, 18; donax anatinus, 18; myra, 18; lutraria, 18; anatina, 18; gastrochœna, 18; clavagella, 18; toredo, 18; watering-pot shell, 18; aspergillum vaginiferum, 18; cymba olla, 19; magilus, 19; patella, 19; nudibranchiata, 19; cypræa turdus, 19; helix aspersa, 19; garden snails, 19; sea snails, 19; eulima, 19; manella, 19; triton, 19; muricidæ, 20; murex tenuispina, 20; murex adustus, 20; scalaria pretiosa, 20; pterocerus, 20; rostellaria ampla, 20; vermetus, 20; siliquaria, 20; cowry, 20; cipræa, 20; helicidæ, 20; gibbus lyonetti, 20; volutes, 24; living mollusks, 24; olivæ, 24; neritidæ, 24; auriculidæ, 24; muricidæ, 24; hermit crabs, 24; bulmius, 24; vegetable feeders, 24; dog

whelk, 25; mya, 25; ear-shell, 25; keyhole limpet, 25; siliquaria, 25; lamp shells, 25; Waldheimia Australis, 26; terebratula, 26; gasteropod, 26; rhynchonella, 26; lingula, 26; terebratula, 26; discina, 26; wing shells, 27; nautilus, 27; argonauta, 28; ianthina, 28; calamary, 28; spirula, 28; pearly nautilus, 29; oysters on mangroves, 66; mammoth, and its epoch, 70; food of heron, 79; caterpillars' eyes, 80; glass-rope hyalonema, 81; hyalonema Sieboldi, 81; spongicolæ, 82; palythoa, 84; Indian insects, 110; flying bugs, 111; coleoptera, 111; bulbocerus, 112; cimicidæ, 112; hemiptera, 112; orthoptera, 112; neuropteous insects, 112; black ants, 112; termites, 112; telerpeton elginense, 159; bee eggs and their products, 160; shell-fish, 162; sea oysters, 162; scollops, 162; pectens, 162; sea-mussel, 162; cockles, 163; clams, 163; gnathodon cuneatus, 163; razor fish, 163; patella, 163; oyster-catcher, 163; haliotis, 163; whelks, 163; buckies, 163; litorina litorea, 164; amphibola, 164; land-snails, 164; helix, 164; cuttle-fish, 164; sea hare, 166; gulls, 173; birds' feathers, 174; rumination in fish, 190; mammalia, 190; scarus, 191; fresh-water valved vaginicola, 205; birds of Norfolk, 235; British fossil oxen, 238; gregarinæ, 239; tadpole, 239; polypes of hyalonema, 239; mammoth in bay of Tas, 240; new oak-feeding silk-worm of China, 241; bombyx mori, 241; ailanthus worm, 241; antheræa pernyi, 241; chrysalis, 242; cocoons, 243; grubs, 243; parasites, 264; sun birds, 249; cinnyris famosa, 249; cinnyris violacea, 249; melliphaga cassiæ, 249; gray finches, 249; acræa horta, 249; pyrameis cardui, 249; eagles, 251; water fowls of Cape Colony, 254; geese, 255; ducks, 255; graptolites, 283; hydrozoa, 285; trophosome, 286; polypary, 286; polypites, 286; diplograpsus, 287; metiolites, 288; phyllograptus, 288; slow incubating silk moth eggs, 320; British woodpeckers, 322; graptolites, 365; rastrites, 368; graptolithus, 368; cyrtograpsus, 369; didymograpsus, 369; dichograpsus, 369; clodograpsus, 369; dendrograptus, 370; diplograpsus, 370; climacograpsus, 370; metiolites, 370; dicranograptus, 371; phyllograptus, 371; polyzoa, 373; hydrozoa, 373; mimetic butterflies, 399; birds' nests, 413; rooks, 416; crows, 416; larks, 416; king-fishers, 416; swallow, 416; wren, 416; magpie, 416; titmouse, 416; pigeons, 416; caprimulgidæ, 416; corixa mercenaria, 467; Ehrenberg on hyalonema, 480.

Nautilus, 28.
Nebulæ, 277, 384, 459.
Necklaces, ancient, 4.
Negative slip of screw propeller, 427.
Neretidæ, 24.
Nest making of the woodpecker, 323.
Nests of various birds, 415.
Neuropterous insect, 112.
New Zealand vegetable sheep, 128.
Nilsson the Swedish naturalist, 372.
Nimrod collection of jewels, 3.
Nineveh collection of jewelry, 3.
Northern lights, 393.
Norman church at St. Margaret's-at-Cliffe, 471.
North-west peninsula of Iceland, 318.
Notes on the crater Linné, 214.
Notes on fossils recently obtained from the Laurentian rocks of Canada, 398.
Note of woodpecker, 324.
Notonecta, 469.
November meteors, 320.
Nudibranchiata, 19.
Nunnery in Wiltshire, 356.
Nutrition considered microscopically, 329

Oak-feeding silkworm of China, 241.
Oars, use of, 421.
Objects, double stars, occultation, 459.
Object-glasses, Wray's, 160.
Occlusion of carbonic oxide, 458.
Occlusion of gases, 452.
Occlusion of hydrogen by meteoric iron, 397.
Occultations, 60, 151, 205, 283, 387, 467.
Ogygia buchii, 351.
Oil lamps for lighthouses, 332.
Olivæ, 24.
Onycha, Blatta Byzantina, 165.
Opals of California, 480.
Operculated gasteropoda, 23.
Ophthalmic use of sulphate of soda, 479.
Optical experiments, 140.
Orchard oriole's nest, 419.
Origin of solar spots, 445.
Orioles' nests, 420.
Orthoptera, 112.
Osteo-plastic, or os-artificial, 184.
"Othello and Desdemona," painted by Maclise, 359.
Oxen fossils, 238.

Oxygen economically produced for industrial purposes, 474.
Oxygen or chlorine, new process for obtaining, 229.
Oxyhydrogen lime light, 226.
Oysters, 162.
Oysters on mangrove trees, 66.

Paarl mountain, 247.
Paddle-wheels, 421.
Palladium tube, 455.
Palm swift's nests, 420.
Palm-leaf huts, 414.
Palythoa, 91.
Panoramic photographs, 313.
Paper nautilus, 28.
Parachutes, 376.
Parasites on wheat, 264.
Partridges of Cape Colony, 251.
Passage of gases through metals, 454.
Parallels of heat, 114.
Patella, 19.
Patella, or rock limpet, 163.
Pearl fisheries, 170.
Pearl producing shells, 170.
Pearly nautilus, 29.
Pecking propensities of the woodpecker, 323.
Pectens, 162.
Pelican's flight, 375.
Penetration of gases, 454.
Pennatula, 373.
Permanent artistic decoration of wall surfaces, 409.
Perjury, 103.
Petrifaction, 284.
Petroleum lamp, new, 64.
Petroleum in Sicily, 80.
Phantom thumbs, 160.
Pharos of Alexandria, 325.
Philosophy of birds' nests, 413.
Physical geography, 477.
Phosphorescent spots on the moon, 51.
Photographs, Mrs. Cameron's, 30.
Photographic negatives, 314.
Photographs of eminent medical men of all countries, 477.
Photography as a fine art, 30.
Photographic instrument, 473.
Photographing the moon, 239.
Photography, new application of, 314.
Photography, Rutherford's celestial, 79.
Photography under water, 64.
Phyllograptus, 371.
Picus, 321.
Picture-notes, Royal Academy, 357.
Pigeon's nests, 416.
Pinna, 171.
Planet Mars, 80.
Plateau's liquid, 160.
Platinum, 180. [181.
Plating or platinizing of various metals,
Pleasant ways in science, 136.
Plumage of woodpeckers, 324.
Pneumatic despatch, 474.
Poisons of spreading diseases, 400.
Polycrates' ring, 402.
Polygonal lens, 327.
Polyps of the Hyalonema, 239.
Polyps, notes on, 84.
Polyzoa, 373.
Poppy, a curious anomaly, 447.
Porcelain glazing, 396.
Positive slip of screw propeller, 426.
Pottery found at Penzance, 223.
Power of birds to hear and remember, 418.
Practice and procedure of the Star Chamber, 95.
Precious stones, 402.
Prehistoric art, 320.
Prehistoric remains of Denmark, 472.
Preparations for wall-painting, 411.
Preservative coatings for metals, 227.
Probable connection of comets with shooting stars, 390.
Proceedings of learned societies, 159, 238, 315, 397, 476.
Proclus, 53.
Production of blacks by the Daguerreotype process, 231.
Products of volcanic action, 218.
Production of iron from copper ore, 230.
Progress of invention, 63, 156, 226, 310, 396, 473.
Projection of sun's image, 431.
Promotheus' ring, 402. [421.
Propelling vessels, various modes of,
Propulsion of boats and ships, 421.
"Prospero and Miranda," by Mrs. Cameron, 33.
Protection of armour plates from corrosion, 397.
Pseudoscope, 476.
Pteroceras, 20.
Pumpkins, monstrosities, 448.
Punishments in olden times, 107.
Purple martin's nest, 419.
Pyrrhus's agate, 403.
Pyx, trials of, 10.

"Rachel," painted by Goodall, 364.
Radiant forces, 136.
Rainy season of India, 110.
Ramble in Cape Colony, 246.
Ramble in West Shropshire, 185, 348.
Ranilla, 19.
Raoulia Australis, raoulia bryoides, and other species, 129.
Rastrites, 366
Rays diverging, 138.
Reason and instinct, 413.
Red mangrove, 67.

Red stars, double stars, nebulæ, Linné and Aristoteles, occultation, 275.
Reflectors, 177.
Reflectors for lamps, 326.
Reindeer horn and bones found at Wirtemberg, 450.
Reliability of electric light, 333.
Relics found at Thebes, 2.
Relics of Queen Aah-hept, 3.
Reliquary, 155.
Researches into the diffusion of gases, 452.
Researches on solar physics, 157.
Restoration of ancient ecclesiastical frescoes, 413.
Results of meteorological observations made at Kew Observatory, 44, 294.
Retention of ecclesiastical frescoes, 413.
Retiolites, 366.
Revolving lights, 327.
Rhæticus, true form of, 267.
Rhinoceros, 70.
Rhinosterbosch, 252.
Rhizophora (mangrove), 65.
Rhynchonella, 26.
Rings, ancient, 6.
Rings first worn, 402.
Rings sent to Carthage, 403.
Ring of Midas, 403.
Ring of Polycrates, 402.
Riot, laws against, 105.
Rock, sculptured, 75.
Roll of exchequer, 98.
Roll of the mint, 10.
Roman antiquities, exhibition of, 472.
Roman building, Gurnard Bay, 154.
Roman candle found near Shelve, 355.
Roman candlestick, 355.
Roman leaden coffins, 310.
Roman lead mines, 354.
Roman remains, Cirencester, 226.
Roman sepulchral remains, 308.
Roman spade, 355.
Roman town of Derventio, 77.
Roman villa, 224.
Roman villa at Linley, 355.
Roman Uriconium, 309.
Rostellaria ampla, 20.
Rooks' nests, 416.
Rutherford's celestial photography, 79.
Rumination in fish, the scarus of the ancients, 190.
Royal Academy, 357.
Royal Microscopical Society, 239, 399, 476.
Royal Society, 397.

Sails as a means of propulsion, 421.
Scalaria pretiosa, 20.
Scalariform graptolites, 366.
Scallops, 162.
Scansors or climbers, 321.
Scarus of the ancients, 190.
Scarus cretensis, 194.
Schmidt, notes on crater Linné, 216.
Schmidt on Linné, 152.
Schröter's investigations, 53.
Schröter's meteors—the lunar Cassini—crimson star—occultations, 144.
Schuylkill coal district, 36.
Science, pleasant ways in, 136.
Screw propeller, 422.
Sculptured rocks, 75.
Sea-hare, 166.
Sea-oysters, 162.
Sea-snails, 19.
Secchi on Linné, 222.
Sensitive litmus paper, 315.
Serpentis, 466.
Self-registering electric thermometer, 228.
Separating power of telescopes, 400.
Separation of gases, 452.
Sepia ink, 166.
Shadows during the solar eclipse, 237.
Shafting, step for, 227.
Shell cameos, 168.
Shells, construction, growth, and form, 18.
Shell-fish as an article of food, 161.
Shell-mounds of Denmark, 162.
Shells as ornaments, 167.
Shells used as bait, 169.
Shells used as lime, 171.
Shells used in medicine, 165.
Shells used as receptacles, 169.
Shell trumpets, 168.
Shih-keue-ming, shells of Haliotis funebris, 165.
Shih-yen, fossil shells, 165.
Shooting-stars connected with comets, 390.
Shropshire rambles in the west, 185.
Signs and symbols of telegraphy, 40.
Silex in wheat, 315.
Silicious coil, 88.
Silicious spicules, 83.
Siliquaria, 25.
Silk crops, 242.
Silk, different qualities produced by different silk-worms, 242.
Silk-moth eggs, slow incubating, 320.
Silkworm cocoon, 243.
Silkworm grubs, 243.
Silkworm, oak-feeding, 241.
Silurian life, 240.
Silvered mirror telescopes; their merits and disadvantages, 176.
Silver, inlaid, 183.
Simultaneous concealment of Jupiter's satellites, 79.
Sir David Brewster's improvement in lighthouses, 327.
Size used in distemper painting, 409.

Slip of screw propeller, 426.
Snails, 19.
Snail's land, 164.
Soirée of the Royal Microscopic Society, 316.
Solar diameter, 437.
Solar eclipse, 240.
Solar eclipse, shadows during, 237.
Solar phenomena, 430.
Solar physics, 157.
Soldering jewelry among the ancients, 4.
Song of birds, 417.
Sonorous vibrations a means of measuring minute portions of time, 311.
South Foreland lighthouse, 328.
Sparrows' nests, 419.
Spectrum of Mars, 319.
Spectacles, hints on, 234.
Spirula, 28.
Sponges, 84.
Spontaneous generation experiment, 80.
Spots on the sun resembling a human skeleton, 436.
Spurious disc of stars, 463.
Sprengel's mercurial exhauster, 453.
Stability of gun cotton, 399.
Staining of wood, 231.
Standards of weight of the Royal Mint, 15.
Star chamber, its practice and procedure, 95.
Steel engraving, 396.
Stellar clusters, noticeable features, 463.
Step for shafting, 227.
Stereochromy, 409.
St. Hilary church, 153.
Stiperstone range, 188, 348.
Strozzi collection from Rome, 401.
Structure of hyalonema, 86.
Sulphuret of carbon to the preparation of perfumes, 312.
Summer of 1783, 127.
Sun's rotation, 159.
Sun screen, 319.
Sun-viewing and drawing, 429.
Swallow's nests, 416.
Swallow's wings, 376.
Swatara coal district, 36.
Swedenborg's biography, 300.
Susquehannah coal district, 38.
Syringings of phosphate liquor and baryta-water, 412.

Tadpole, organs of, 239.
Tanning principle, 310.
Telegraphic communication by means of numerical code, 40.
Telegraphic letters, 41.
Teleology of form, 29.
Telerpeton Elginense, new specimen, 159.
Tellina solidula, 18.
Telescopes, new, with silvered glass specula, 234.
Telescopes, separating power of, 400.
Telescopes, silvered mirror, 176.
Telescopic meteors, 145.
Tempel's comet and shooting-star, 159.
Temperate antarctic zone low barometer, 334.
Temperature, mean annual, 114.
Tents of the Arabs, 414.
Terebratula, 26.
Termites, Indian insects, 112.
Textile fibres, 313.
Three-toed woodpecker, 326.
Titmouse's nest, 416.
Tonka bean, 256.
Toreda, 18.
Torricellian vacuum, 452.
Toucani cluster, 464.
Tour de Corduan, 326.
Tracy park, Roman villa, 224.
Trade winds, 335.
Transmission of light, 142.
Transparency of red-hot iron, 400.
Tremadoc slates, 349.
Treveneage cave, 74, 153, 223.
Trial of the pyx, 10.
Trials by Star Chamber, 104.
Trial by jury, 104.
Triton, 19.
Trophosome, 286.
Tumuli in Yorkshire wolds, 393.
Twin records of creation, or Geology and Genesis, 233.
Tyrian purple, 166.

Vaginicola aquatica valvata, 206.
Vaginicola, valved fresh water, 205.
Vaginicola valvata, 320.
Variation of species, 319.
Various modes of propelling vessels, 421.
Vegetable feeders, 24.
Vegetable fibre dissolved, 476.
Vegetable monstrosities and races, 446.
Vegetable sheep of New Zealand, 128.
Venus's comb, 20.
Vicat Cole's marine painting, 364.
Vindomis of Antonine itinerary, 470.
Vindomis, Roman remains, 470.
Volcanic action, product of, 218.
Volutes, 23.

Waldheimia Australis, 26.
Wall decorations, never drying, 411.
Water glass, 411.
Water glass fresco, 409.
Water supply to ancient towns, 257.
Waterproof cement, 315.
Watering-pot, shell, 18.
Waterwitch, experiments, 428.
Weakness of wheat stems, 479.

Weight of aqueous vapour, 344.
Wells, 259.
Wentle trap, 20.
West Shropshire rambles, 344.
Wheat stems, weakness of, 479.
Whelk, notes on, 163.
White cloud illumination for low powers, 292.
Wild fowl of Cape colony, 253.
Willow leaf, or rice grain entities of the sun's face, 430.
Wiltshire nunnery, 356.
Wing-shells, 27.
Winter of 1768, 127.
Wire ornaments, 6.
Wood engraving, art of, 234.
Woodpeckers, British, 321.
Wray's object-glasses, 160.
Wren's nests, 415.

Zoophytes, 85.

ILLUSTRATIONS.

ILLUSTRATIONS IN COLOURS.

	PAGE
Ancient Jewelry	1
Hyalonema Sieboldi	81
Vegetable Sheep	128
Oak Feeding Silkworms	241
British Woodpeckers	321
Cameo of the Emperor Augustus in the Blacas Collection	401

TINTED PLATES.

Mangroves	65
Economic Use of Shells	161
Biela's Comet	208
British Graptolites	369
Various Solar Spots	432

ENGRAVINGS ON WOOD.

Tellina solidula	18
Donax anatinus	18
Forms of Marine Shells	21
Mountain of Swatara	37
Light Spots in Lunar Night	53
Hyalonema	93
Diagram of Mean Annual Isotherms of London	115
Diagram of Annual Variation of Mean Diurnal Temperature at Greenwich	123
Corolla and Achene of Vegetable Sheep	134
Leaf of Vegetable Sheep	135
Diagram of Light-spots	144
Vaginicola Aquatic Valvata	206
Diagrams of Lunar Perspective, 269, 270, 273,	274
Fac-simile of the Figure of Graptolithus scalaris	284
Diagram of Barometric Pressure, 336,	346
Ingot of Lead from Linley	354
Spade found in Roman Mine	355
Roman Candle	355
Diagram of darkening Shutter for viewing the Sun by projecting on a Screen	432
Dr. Sprengel's Mercurial Exhauster	453
Apparatus for Heating Metal and Transferring Gas	456
Eggs of Corixa Mercenaria	468

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